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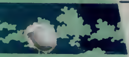

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RIT-86-8503

Prepared for:

Resource Indemnity Trust Grant Program
Montana Department of Natural Resources and Conservation

Prepared by:

GARY L. INGMAN

State of Montana
Department of Health and Environmental Sciences
Water Quality Bureau
Cogswell Building
Helena, Montana 59620

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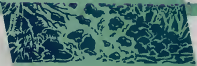

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1. INTRODUCTION

In late 1983, the Montana Department of Health and Environmental Sciences (DHES) found itself embroiled in a controversy over whether to modify an existing wastewater discharge permit for the Champion International kraft mill at Frenchtown to allow year around discharge of effluent to the Clark Fork River. The debate generated intense public interest. The end result was that federal, state and private funding was appropriated to conduct a comprehensive water quality study of the lower 230 miles of the Clark Fork. Until then, little water quality data existed upon which to base water quality management decisions in Montana's largest river basin.

By late 1985, much more was known about the quality of the lower Clark Fork thanks to the efforts of many researchers. But even more questions and concerns were raised than were answered. In view of a multitude of planned development and pollution abatement activities in the basin and heightened public interest, the need for more information, and especially long-term information became apparent. In late 1985, DHES applied to the Montana Department of Natural Resources and Conservation (DNRC) for Resource Indemnity Trust Grant Program (RIT) funding of a comprehensive water quality monitoring program for the entire Clark Fork River. Funding was approved by the 198~~6~~5 Montana legislature. Subsequently, an application was submitted and approved (by 1987 legislature) for a two-year continuation of RIT funding through State fiscal year 1989.

This report describes that monitoring program and summarizes the first year's monitoring results.

1.1 Background

The Clark Fork is our state's largest river and a key resource for western Montana and northern Idaho. Originating along the Continental Divide near Butte and Anaconda, the river drains an area of more than 20,000 square miles before crossing the Montana-Idaho border. In Idaho, the river provides the majority of inflow to Lake Pend Oreille, a clear, cold, and very deep natural body of water and popular recreation area similar to Montana's Flathead Lake.

Over 120 years of mining, mineral processing, agriculture, timber harvesting, hydropower development, and population growth have adversely affected the Clark Fork river system. Some have described the Clark Fork as the most polluted watershed in Montana. Mine activities have denuded hillsides, left empty pits, and sterilized whole streams in the headwaters. Water quality has been affected as far downstream as Milltown Dam, where tailings have been concentrated and the adjacent groundwater and a municipal drinking water supply have become contaminated with arsenic. In between, the floodplain has been contaminated with copper and other heavy metals. Hydroelectric dams have altered natural streamflows and degraded water quality. Municipal and industrial wastewaters have added nutrients to the river, and agricultural and timber harvest practices have contributed to water quality degradation.

Throughout the Clark Fork River Basin, there is a high degree of public concern for water quality issues, and a strong desire to preserve and enhance the river's resource potential. The Department of Health and Environmental Sciences has designated the Clark Fork River as a priority water body and Governor Schwinden has established the Clark Fork River Basin Project to coordinate efforts to maintain or improve water quality. Sewage treatment plants are being upgraded. Montana Power Company has begun the reconstruction of Milltown Dam. The Montana Department of Fish, Wildlife, and Parks is applying for an instream flow reservation on the Clark Fork. Three of

Montana's five Superfund sites plus an Abandoned Mine Lands project (Colorado Tailings) are located in the basin.

At present, the Anaconda Company has ceased operations, the Berkeley Pit is filling with water, and the long-term effectiveness of mine waste treatment ponds (Warm Springs Ponds) is in doubt. Montana Resources has resumed mining and mineral processing on portions of the AMC properties at Butte, and ASARCO and Montoro are planning to open major new metals mines in the basin. The U.S. Forest Service is predicting major increases in sediment yields for forest watersheds. Reclamation activities involving removal of streamside tailings deposits could cause increased metals and sediment pollution.

1.2 Scope and Objectives

Beginning in July, 1986, DHES through coordination with the Governor's Clark Fork River Basin Project, established a comprehensive, long-term fixed-station water quality monitoring program for the entire Clark Fork River. Its purpose is to detect possible violations of ambient water quality standards, to provide data for water quality management decisions (e.g., issuance or reissuance of wastewater discharge permits), to monitor the biological health of the river and to document any changes in water quality that might result from resource development or reclamation and pollution control efforts. Additionally, the data are available to other agencies and researchers and will be an important component of a comprehensive Clark Fork Basin Water Quality Management Plan being prepared by the Governor's office.

2. METHODS

Thirty-one fixed water quality monitoring stations have been established on the Clark Fork River, major tributaries and wastewater discharges (Figure 1). Stations were selected to bracket known or suspected pollution sources, to track pollutant concentrations with increasing distance from sources and to take advantage of existing U.S. Geological Survey (USGS) streamflow gauging stations for river discharge data (Table 1).

The monitoring approach consists of water quality data collection approximately 16 times a year (monthly from August through March, twice monthly from April through July plus additional monitoring during unusual events, if necessary) at each of the stations. Unfiltered grab samples for total recoverable metals (Cu, Zn, As), algal nutrients (total P, O-PO_4, NO3+NO2, NH3-N, total Kjeldahl N), and common ions (Ca, Mg, alkalinity, pH) and depth-integrated samples for total and volatile suspended sediments are colllected at each station on each visit. Streamflows are gauged or flows are obtained from USGS measurements. Stream temperatures and field notes are also recorded. Once each year in August, biological samples consisting of four modified Hess quantitative macroinvertebrate samples and one periphyton composite sample are collected at each river or tributary station. Diel sampling of water temperature and dissolved oxygen is conducted at selected stations during the warmest part of the summer (July or August).

Field sampling is conducted according to the DHES Water Quality Bureau's standard procedures. Chemical and sediment analysis methods are EPA-approved methods used by the DHES Chemistry Laboratory Bureau which performs all such analyses. Macroinvertebrate samples are processed by a qualified biological consultant. Periphyton sample analyses are performed by Water Quality Bureau experts.

Water quality data are compiled and entered on the Water Quality Bureau data management file and subsequently transferred to the EPA STORET data file. A computerized

spreadsheet data analysis system has been developed to facilitate the assessment of trends for metals, nutrients and suspended sediment. At the present time, biological data are being handled manually. However, these data will be computerized in the near future.

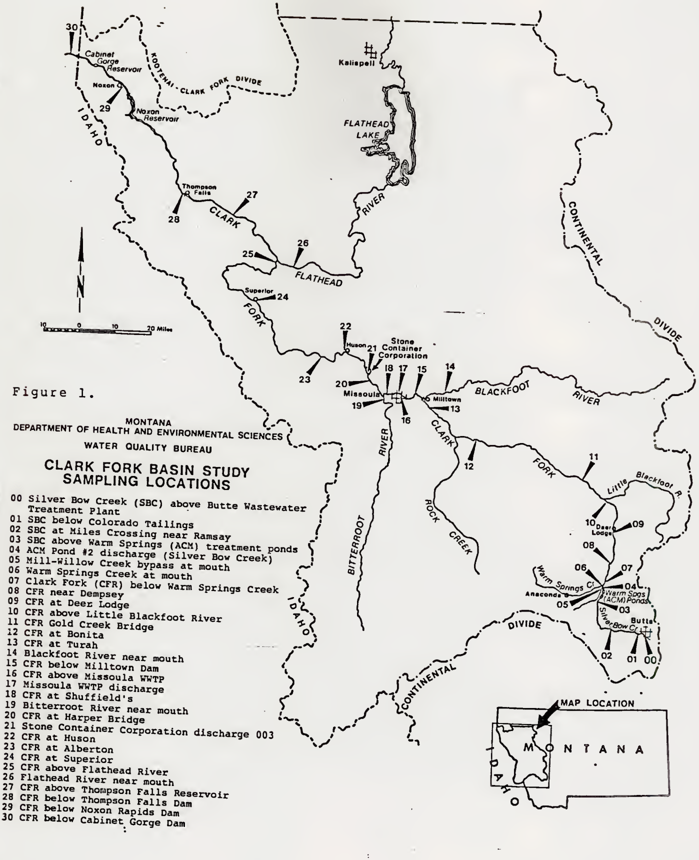

Figure 1.

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CLARK FORK BASIN STUDY SAMPLING LOCATIONS

00 Silver Bow Creek (SBC) above Butte Wastewater Treatment Plant
01 SBC below Colorado Tailings
02 SBC at Miles Crossing near Ramsay
03 SBC above Warm Springs (ACM) treatment ponds
04 ACM Pond #2 discharge (Silver Bow Creek)
05 Mill-Willow Creek bypass at mouth
06 Warm Springs Creek at mouth
07 Clark Fork (CFR) below Warm Springs Creek
08 CFR near Dempsey
09 CFR at Deer Lodge
10 CFR above Little Blackfoot River
11 CFR Gold Creek Bridge
12 CFR at Bonita
13 CFR at Turah
14 Blackfoot River near mouth
15 CFR below Milltown Dam
16 CFR above Missoula WWTP
17 Missoula WWTP discharge
18 CFR at Shuffield's
19 Bitterroot River near mouth
20 CFR at Harper Bridge
21 Stone Container Corporation discharge 003
22 CFR at Huson
23 CFR at Alberton
24 CFR at Superior
25 CFR above Flathead River
26 Flathead River near mouth
27 CFR above Thompson Falls Reservoir
28 CFR below Thompson Falls Dam
29 CFR below Noxon Rapids Dam
30 CFR below Cabinet Gorge Dam

Table 1. Clark Fork Basin Monitoring Station Descriptions

Number	Station Name	Legal Description	River Mile	Average Annual Flow (cfs)	Station Rationale
00	Silver Bow Creek above Butte wastewater treatment plant (WWTP)	T3N R8W Sec. 23 DAD	0.0	--	Control station above Butte WWTP.
01	Silver Bow Creek below Colorado tailings	T3N R8W Sec. 22 ACA	1.0	25.6	Station is located a short distance below Butte WWTP. Colorado Tailings are a Superfund site and a significant source of metals.
02	Silver Bow Creek at Miles Crossing near Ramsay	T3N R9W Sec. 16 ACC	11.0	--	Station is located below additional streamside tailings.
03	Silver Bow Creek at frontage road above Warm Springs Ponds	T4N R10W Sec 02 DD	22.0	--	Control station above Warm Springs treatment ponds.
04	Warm Springs Pond 2 discharge (Silver Bow Creek)	T5N R9W Sec. 19 BAB	26.0	--	Station allows comparison of water quality from above to below ponds.
05	Mill-Willow Bypass near mouth	T5N R9W Sec. 19 BB	26.0	--	A major tributary to the upper Clark Fork with variable water quality.
06	Warm Springs Creek near mouth	T5N R9W Sec. 18 DBB	27.5	64.6	A major, relatively clean tributary to th upper Clark Fork.
07	Clark Fork below Warm Springs Creek	T5N R9W Sec. 18 AC	28.0	--	The Clark Fork just downstream of its point of origin.
08	Clark Fork near Dempsey	T6N R9W Sec. 21 BBB	36.0	--	Streamside tailings deposits are located in this reach.
09	Clark Fork at Deer Lodge	T7N R9W Sec. 09 BAB	49.0	343	Streamside tailings deposits are located in this reach. Also a control station above the Deer Lodge WWTP.
10	Clark Fork above Little Blackfoot River	T9N R9W Sec. 30 DA	64.0	--	Streamside tailings deposits are located in this reach. Also a test station below the Deer Lodge WWTP and a control station above the Little Blackfoot River.

Table 1. Continued.

Number	Station Name	Legal Description	River Mile	Average Annual Flow (cfs)	Station Rationale
11	Clark Fork at Gold Creek	T10N R11W Sec. 25 CBD	74.5	677	Test station below L. Blackfoot River and Gold Creek.
12	Clark Fork at Bonita	T11N R16W Sec. 10 DDC	124.5	1021	Station in area of depressed trout population. Control station above Rock Creek.
13	Clark Fork at Turah	T12N R18W Sec. 01 CBC	141.5	--	Test station below Rock Creek and above Blackfoot River and Milltown Reservoir.
14	Blackfoot River near mouth	T13N R17W Sec. 09 BDD	147.5	1636	A major, clean tributary to the middle Clark Fork.
15	Clark Fork below Milltown Dam	T13N R18W Sec. 18 CBC	150.0	3037	Milltown Reservoir is a designated Superfund site and has trapped large quantities of metals originating upstream in the Clark Fork drainage.
16	Clark Fork above Missoula wastewater treatment plant	T13N R19W Sec. 18 DDA	157.4	3037 (Est.)	Control station above Missoula WWTP.
17	Missoula wastewater treatment plant discharge	T13N R19W Sec. 18 DDA	157.5	10.8*	Large volume point source municipal wastewater discharge to Clark Fork.
18	Clark Fork at Shuffield's	T13N R20W Sec. 24 AAD	159.5	3037 (Est.)	Station allows examination of effects of Missoula WWTP after complete mixing.
19	Bitterroot River near mouth	T13N R20W Sec. 26 CBD	162.5	2486 (Est.)	A major clean tributary to the middle Clark Fork
20	Clark Fork at Harper Bridge	T14N R21W Sec. 35 ADA	170.0	5523	Control station above Stone Container kraft mill and a test station below the Bitterroot River.

---

* Average discharge in State FY 1987.

Table 1. Continued.

Number	Station Name	Legal Description	River Mile	Average Annual Flow (cfs)	Station Rationale
21	Stone Container Corporation wastewater discharge	T14N R21W Sec. 14 BBC	173.5	8.0*	A large volume point source industrial discharge to the Clark Fork.
22	Clark Fork at Huson	T15N R22W Sec. 26 ACB	182.0	5523 (Est.)	Test station below Stone kraft mill.
23	Clark Fork near Alberton	T14N R23W Sec. 12 AAB	192.5	5523 (Est.)	Stations 23 and 24 allow examination of the effects of the Missoula WWTP and Stone discharges and other pollutants (e.g. metals) with increasing distance from their sources.
24	Clark Fork at Superior	T17N R26W Sec. 34 AAB	230.5	--	
25	Clark Fork above Flathead River	T19N R25W Sec. 33 DAD	270.0	7555	Control station for Clark Fork water quality above Flathead River.
26	Flathead River near mouth	T18N R24W Sec. 05 DDC	270.5	11235	A major, clean tributary to the lower Clark Fork.
27	Clark Fork above Thompson Falls Reservoir	T21N R27W Sec. 33 BCB	294.5	19950	Control station above Thompson Falls Reservoir. Also, test station below Flathead River.
28	Clark Fork below Thompson Falls Dam	T22N R30W Sec. 36 BDC	314.5	20666 (Est.)	Station allows comparison of water quality from above to below the reservoir. It also serves as a control station above Noxon Rapids Reservoir.
29	Clark Fork at Noxon Bridge	T26N R32W Sec. 19 DAB	351.5	21070	Same rationale as for station 28 and a control station above Cabinet Gorge Reservoir.
30	Clark Fork Below Cabinet Gorge Dam	T27N R3E Sec. 20 DCC	373.5	22370	Same rationale as for station 28 and indicative of water quality entering Idaho's Lake Pend Oreille.

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* Average discharge in State FY 1987.

3. MONITORING RESULTS

In order to evaluate trends in water quality conditions, a monitoring program must maintain a certain amount of continuity. In the Clark Fork system, many factors contribute to pollutant concentrations and the general health of the river at any given time. Streamflows and runoff patterns are perhaps the most important factors. High streamflows provide higher dilution for municipal and industrial wastewater discharges. Conversely, the river's erosive potential is greater during high flows and metals and sediment concentrations tend to increase with increasing flows as streamside mine tailings and soil particles are washed into the river. As a result of variable runoff patterns from one year to the next, the detection of significant trends in water quality over time becomes difficult. Several years of baseline monitoring will be necessary before these normal variations in water quality conditions can be distinguished from man-induced changes.

The 1986-1987 water quality and biological data have made it possible to take a general look at conditions throughout the river system for the first time. Cause and effect relationships and spatial trends are discussed but for obvious reasons, year to year (or temporal) trends in river conditions cannot be assessed. Given the two-year continuation of monitoring funds through FY 1989, and the availability of earlier water quality data for some situations, patterns in the year to year variation in pollutant concentrations and the biological health of the river will begin to emerge. Collectively the data should provide an adequate basis for the detection of longer term improvements or deterioration in Clark Fork water quality.

Monitoring results and downstream trends in Clark Fork water quality are discussed in the following pages. A first section explains the surface water quality data analysis methodology and summarizes surface water quality trends in the Clark Fork and major tributaries for the monitoring period. Subsequent sections consist of individual reports addressing each

of the following aspects of the monitoring program: 1) macroinvertebrate community structure, 2) periphyton community structure, and 3) results of the diel dissolved oxygen and temperature surveys conducted in summer, 1986.

Each of the individual reports contain its own table of contents, figures, tables, appendices and page numbering system.

3.1 Surface Water Quality

3.1.1 Data Management Program and Water Quality Trends Assessment Scheme

As a result of the large number of sampling stations, parameters measured and the frequency at which they were measured, a very large body of water quality data was generated over the course of the year. Consequently, computerization was necessary to summarize the water quality conditions at each station and assess downstream trends.

All water quality data generated by the Water Quality Bureau are entered into a centralized data management system. This information is periodically entered into the U.S. Environmental Protection Agency STORET data base. However, no program was readily available to manipulate and interpret river quality data with the specific objectives of the Clark Fork Basin Water Quality Monitoring Program in mind. During the first year of monitoring, a system was designed to:

1. catalogue chemical and suspended sediment data by station and state fiscal year,
2. compute key statistics such as loads of pollutants and monthly and annual average pollutant values, by station and year,
3. calculate criteria values for the protection of specific beneficial water uses using published formulas and appropriate measurement data (e.g., water hardness for metals toxicity, pH and temperature for ammonia toxicity).

4. determine the annual frequency and average magnitude of exceedence of the water quality criteria for each specific parameter at each monitoring station, and
5. evaluate the degree of problem for a specific parameter or group of parameters between stations and from year to year through the use of a pollutant severity analysis scheme which was developed.

The system was developed on a spreadsheet format using Lotus 1-2-3 software so that raw data, data statistical summaries and the data evaluations could be utilized directly in reports or be made available to other individuals.

During the development of the above described data management system, certain assumptions had to be made which will influence the interpretation of the data. These assumptions are discussed below.

Generally, one to two sampling events occurred each month of the year. Monthly mean parameter values were computed from the instantaneous values and annual mean values were computed from the monthly means. In order for the monthly and annual mean values to be representative of actual conditions, the instantaneous sampling events had to take place during conditions which were representative of the interval (i.e. month or half month). Every effort was made to insure that this was the case. For example, streamflows at key stations were monitored by telephone on a daily basis in order to time sampling events. However, river conditions may change quickly and without warning (especially in spring) and monitoring frequency may have been inadequate during periods of unstable streamflow. As a result, some unknown degree of error in the representativeness of the data is inherent in the program. Only increased sampling frequency (at significantly increased cost) would minimize this potential problem.

For some stations, during certain times of the year,

various pollutant concentrations fell below their respective analytical detection limits. In those instances, the data are reported as "less than X ug/l". In the computation of mean values and pollutant loads (pounds/day or tons/year), it was necessary to assign a value to those measurements which fell below the analytical detection limit. Four options were available: 1) Assume that the measurement was at the detection limit for the sake of the computations, 2) assume the value was zero, 3) assign an arbitrary value based on regression analyses, or 4) use the midpoint between the detection limit and zero. This problem has long been the centerpiece for debate and each option has its inherent problems. For the sake of simplicity, the second option was chosen. This method consistently underestimates mean values and loads but it is also conservative and does not identify problems where they may not, in fact, exist. Data is not currently available to use option 3) or to determine the suitability of option 4).

Criteria for the protection of freshwater aquatic life were utilized in the computerized evaluation of metals, sediment and ammonia data. For these evaluations to be representative of the suitability of water quality in the Clark Fork Basin for other beneficial water uses, these aquatic life criteria must be at least as low as the criteria for any other water uses for which the Clark Fork is classified. In other words, the assumption used is that if water quality is adequate to protect aquatic life, other beneficial uses will not be precluded. With one exception, this assumption holds true. The arsenic criterion for the protection of freshwater aquatic life is 190 ug/l while the federal drinking water standard is 50 ug/l. As a result, arsenic data were manually reviewed for exceedences of the drinking water standard.

Given these assumptions, a discussion follows as to how the system works for each of three parameter groups.

METALS

Spreadsheets for metals data for each monitoring station are included in Appendix A. On page one of the five page set for each station, instantaneous measurement data are presented together with statistical summaries showing the number of measurements and maximum, minimum and mean values. The layout is self explanatory. Because sampling frequency is increased during spring runoff (twice as many spring measurements as during the remainder of the year), mean values of the instantaneous measurement data are not representative of "average" conditions; means are skewed toward runoff condition because there are more data points available for the spring period. Page two presents monthly average data values for each parameter and statistical summaries of those data. These data are more representative of monthly and yearly average conditions in the river. Also included on page two are figures for annual loads of pollutants in units of tons per year. Those data should be interpreted with caution because in a few cases, some streamflow data were unavailable at the time this report was prepared. As a result, a load could not be computed for a given month and the annual load will be underestimated. Secondly, where values were less than the analytical detection limit, a zero load will be generated because of the reasons described earlier. The annual pollutant load data are useful for general trend assessment but they should be considered as "ballpark" figures until the missing streamflow data is available and the figures can be carefully reviewed.

At the bottom of page two, the frequency and average magnitude of exceedence of both EPA chronic and acute toxicity criteria for each metal is presented. The chronic and acute criteria for copper are floating values that are calculated from water hardness, as is the acute criterion for zinc. The chronic zinc criterion and the chronic and acute arsenic criteria are fixed values of 47, 190 and 360 ug/l, respectively. Frequency is calculated on the basis of instantaneous measurements, i.e. one exeedence in two measurements during a given month would result

in a 50 percent frequency of exceedence for the month and this would be reflected in the annual frequency of exceedence value that is presented. Magnitude of exceedence indicates that, based on the annual mean value for a metal, the average concentration was "X" times the criterion value. While not particularly significant from the standpoint of toxicity, the magnitude value does indicate how severe the problem is at a given station and how far concentrations would need to be reduced, on the average, to prevent criteria exceedences.

Following the frequency and magnitude values are individual metals severity scores for each metal and a cumulative severity score (additive) for all three metals. The severity score is the product of frequency times magnitude. Again, the severity score may not be particularly meaningful from the standpoint of toxicity. However, the scoring system does provide a quick reference to the degree of metals problem between stations throughout the river basin.

Pages three through five of the metals spreadsheet present individual assessment data of loads and frequency and magnitude of criteria exceedences for each of the three metals.

NUTRIENTS

Nutrient data evaluation spreadsheets are also included in Appendix B. The data are evaluated in a comparable manner to the metals results, except the criteria are different. Phosphorus and nitrogen are not considered to be toxic substances in aquatic systems but they have other indirect deleterious effects. Criteria used are values for total phosphorus and total soluble inorganic nitrogen (50 and 1000 ug/l, respectively) that should not be exceeded to prevent excessive developments of attached algae in rivers and to prevent eutrophication in lakes which are fed by rivers. These specific criteria are the subject of current debate and may be replaced by other criteria in the future. Individual nitrogen and phosphorus severity scores are computed as is a cumulative severity score, like for metals.

Ammonia is a nitrogenous compound that can produce toxicity to aquatic life under certain conditions of temperature and pH. The nutrients spreadsheet also contains an evaluation of the frequency and magnitude of exceedences of the ammonia criterion, which is a floating value calculated from the total ammonia concentration and water temperature and pH data. An ammonia severity score is also computed.

SUSPENDED SEDIMENT

Suspended sediment data analysis spreadsheets consist of two pages per monitoring station and they are included in Appendix C. The data are evaluated in a comparable fashion to the metals and nutrients except that criteria used are for the protection of freshwater aquatic communities, including fisheries. No toxicity criteria, per se, are available for suspended sediment. The spreadsheet calculates the frequency of distribution of monthly average suspended sediment values among four levels of protection for freshwater aquatic life: high level (<25 mg/l), moderate level (25-80 mg/l), low level (80-400 mg/l, and very low level of protection (>400 mg/l). A magnitude value is computed using the highest level of protection (25 mg/l or less of suspended sediment) as a basis, with the premise being that 200 mg/l of sediment is four times as bad as 25 mg/l, from the standpoint of aquatic life protection. A suspended sediment severity score is computed from the frequency distribution and magnitude scores (e.g. high level frequency X high level magnitude + moderate level frequency X moderate level magnitude, and so on).

3.1.2 Surface Water Quality Trends

Raw data, statistical summaries and computed water pollution severity scores are given by station and parameter group in Appendices A, B and C. Trends for each parameter group are reviewed in the following pages. As discussed earlier, the

evaluations concentrate on the biological implications of each pollutant, with the premise being that if water quality is adequate to protect aquatic life, other beneficial water uses will not be impaired. A river mile index is provided loose in the front of this report to facilitate the reader's review of the numerous data plots.

Note: Monitoring station 00, Silver Bow Creek above the Butte wastewater treatment plant was established in January, 1987. As a result of incomplete records, data for this station should be interpreted with caution.

METALS

Figures 2 - 7 depict Silver Bow Creek and Clark Fork River total recoverable copper concentrations, frequency and magnitude of exceedence of the criterion to protect freshwater aquatic life and computed copper pollution severity scores by river mile, beginning at Butte, Montana. The same data for total recoverable zinc and arsenic are presented in Figures 8 - 13 and 14 - 18, respectively.

The data confirm that Silver Bow Creek above the Warm Springs treatment ponds is seriously polluted. Highest instantaneous and annual average copper concentrations occurred at station 01, Silver Bow Creek at Miles Crossing near Ramsay, in state fiscal year 1987. Zinc concentrations reached their maximum at the same station while annual average zinc concentrations were highest just below the Colorado Tailings. Toxicity criteria for copper and zinc were exceeded 100 percent of the time in Silver Bow Creek above the treatment ponds with annual average concentrations exceeding the criteria about 20 fold. Arsenic concentrations were an order of magnitude less than either copper or zinc and exceedences of aquatic life criteria were not documented in FY 1987 in either Silver Bow Creek or the Clark Fork River.

Silver Bow Creek below the Warm Springs Ponds showed significantly lower copper and zinc concentrations than above the ponds. Although the aquatic life criteria were exceeded more

than half the time, annual average values were not much higher than the criteria. Thus, exceedences tended to be frequent but slight.

The Clark Fork River at its point of origin below the confluence of Silver Bow and Warm Springs Creeks exhibited further improvements in quality due to a dilution of the treatment pond outflow by cleaner tributaries. The copper criterion was exceeded only 17 percent of the time, while zinc was in excess of the criterion 42 percent of the time during FY 1987.

From Warm Springs Creek to station 10, above the little Blackfoot River, copper and zinc concentrations generally increased, especially during winter and early spring, due to the presence of streamside mine tailings deposits. Copper and zinc created the worst problems at station 10, compared to all other mainstem Clark Fork monitoring locations. Those metals exceeded the criteria about half the time at that station with some measurements exceeding those criteria four to seven times.

Conditions generally improved from station 10 downstream to Idaho, as clean tributary inflows diluted metals concentrations. An exception is a significant spike in copper and zinc concentrations, frequency, magnitude and severity at station 15, below Milltown Dam. The reconstruction of the dam spillway during FY 1987 caused the release of some deposited metal-bearing sediments and the incidents are reflected in the monitoring data. A short distance downriver, the peaks in the graphs disappear. Metals criteria exceedences were rare and short lived in the Clark Fork from below the Bitterroot River to the Flathead River in FY 1987. No exceedences of the criteria were documented as occurring from below the Flathead River to Idaho.

Figures 19 and 20 depict cumulative metals severity scores for Silver Bow Creek and the Clark Fork River in FY 1987.

Figures 21-25 evaluate copper, zinc and arsenic concentrations, frequency of exceedence of aquatic life criteria

and severity scores for the tributaries and wastewater discharges to the Clark Fork River that were monitored. The Mill-Willow Bypass and the Missoula wastewater treatment plant discharge stand out from other stations as sources of copper and zinc. The Mill-Willow Bypass and the Stone Container Corporation wastewater discharge showed above average concentrations of arsenic. The first station routinely exceeded the arsenic drinking water standard (ARM 16.20.203(1) during high flows. Because of their relative contributions to the river, only the Mill-Willow Bypass is considered to be a potentially significant metals problem. That situation is currently being addressed because of its contribution to periodic fish kills in the upper Clark Fork.

Figures 26 - 29 show the periodicity of total recoverable copper concentrations and streamflows at key stations on Silver Bow Creek and the Clark Fork River. The data indicate varying degrees of streamflow dependence of copper concentrations at the stations during the course of the year. Station 01, Silver Bow Creek below the Colorado Tailings and station 10, Clark Fork above the Little Blackfoot River appear to show the greatest fluctuation in concentration and greatest streamflow dependence, presumably due to the proximity of streamside tailings deposits.

NUTRIENTS

Figures 30 - 35 illustrate trends in Silver Bow Creek and Clark Fork River total phosphorus concentrations, frequency and magnitude of exceedence of the criterion to prevent the development of biological nuisances and to control eutrophication and computed phosphorus pollution severity scores by river mile, beginning at Butte, Montana. The same data for total soluble inorganic nitrogen are presented in Figures 36 - 40.

These data indicate that Silver Bow Creek below the Butte wastewater treatment plant discharge suffers from a serious nutrient pollution problem. Highest concentrations of both total phosphorus and total soluble inorganic nitrogen occurred at

station 01, Silver Bow Creek below the Colorado Tailings. The station is located a short distance downstream of the Butte sewage discharge and monitoring during periods of low streamflow indicated that more than half the Silver Bow Creek flow consisted of sewage effluent. From this station downstream to station 03, above the Warm Springs Ponds, phosphorus and nitrogen exceeded the criteria nearly 100 percent of the time. Annual average magnitudes of exceedence ranged to nearly 32 times and greater than four times the criteria for phosphorus and nitrogen, respectively at Silver Bow Creek stations. Ammonia toxicity was also a potential problem at station 01 where the chronic toxicity criterion was exceeded 71 percent of the time. This was the only stream station where ammonia criteria were exceeded.

The Warm Springs treatment ponds appear to have eliminated the nitrogen enrichment problem for lower Silver Bow Creek and the Clark Fork River. The nitrogen criteria were never exceeded in the Pond 2 discharge or at any downstream mainstem stations. Annual average magnitude values ranged to only fractions of the nitrogen criterion. While phosphorus concentrations were also reduced as a result of the treatment ponds, problem levels persisted. Measurements of total phosphorus in the Pond 2 discharge exceeded the criterion 92 percent of the time and magnitudes averaged about three times the criterion.

The trend for phosphorus at downstream stations in the mainstem Clark Fork was one of decreases in severity below incoming clean tributaries followed by temporary spikes below municipal and industrial wastewater discharges. The Deer Lodge and Missoula sewage discharges located at river miles 52 and 158, respectively, had the most striking effects. The Stone Container Corporation wastewater discharge at mile 174 had a less pronounced influence in part due to the large volume, clean inflow of the Bitterroot River a short distance upriver.

The highest phosphorus severity score was computed for station 10, above the Little Blackfoot River (and downstream of the Deer

Lodge sewage discharge), where the phosphorus criterion was exceeded 79 percent of the time. Below the Missoula sewage outfall, the criterion was exceeded a third of the time, with all downstream stations being significantly less. The phosphorus criterion was never exceeded in FY 1987 at stations below the Flathead River confluence.

Figures 41 and 42 depict cumulative nutrient enrichment severity scores for Silver Bow Creek and the Clark Fork River in FY 1987.

Figures 43 - 48 evaluate total phosphorus and total soluble inorganic nitrogen concentrations, frequency of exceedence of the criteria and severity scores for the tributaries and wastewater discharges to the Clark Fork River. In general, the tributaries did not seem to be significant sources of phosphorus or nitrogen to the Clark Fork. While some exceedences of the phosphorus criterion occurred in the Mill-Willow Bypass (station 05) and the Blackfoot (14) and Bitterroot (19) Rivers they were infrequent and associated with runoff conditions. Conversely, the Missoula and Stone Container wastewater discharges were very significant sources of both phosphorus and nitrogen to the Clark Fork, with the former surpassing the latter in both categories. Nutrient loading to the Clark Fork is becoming a major public issue and both facilities are closely monitoring nutrient levels in their discharges.

Figures 49 - 56 show the periodicity of total phosphorus and total soluble inorganic nitrogen concentrations and streamflows at key stations on Silver Bow Creek and the Clark Fork River. Station 01 is located below the Butte sewage discharge, station 10 is below the Deer Lodge sewage discharge and stations 18 and 22 are below the Missoula wastewater plant and Stone Container Corporation kraft mill, respectively. Nutrient concentrations are basically inversely proportional to streamflow at station 01 because the Butte sewage discharge, which is a major source of nutrients, is more dilute in Silver

Bow Creek during runoff conditions. Phosphorus appears to be somewhat proportional to flow for station 10, but there is no clear relationship for nitrogen. Phosphorus concentrations at stations 18 and 22 appear to be at least seasonally flow-dependent while nitrogen concentrations are clearly inversely related to streamflow. A more thorough analysis of the data (regressions) would be necessary to confirm these apparent relationships.

SUSPENDED SEDIMENT

Figures 57 - 59 illustrate Silver Bow Creek and Clark Fork River total suspended sediment concentrations, frequency of exceedence of the criterion to protect freshwater aquatic communities and computed suspended sediment severity scores by river mile, beginning at Butte, Montana.

The data indicated highly variable conditions from station to station in terms of both concentration and severity during FY 1987. The Silver Bow Creek stations 01 - 03 were among the worst, probably as a result of the extent of unvegetated mine tailings in the drainage. The Warm Springs Ponds between stations 03 and 04 caused major reductions in sediment concentration and frequency of exceedence of the criterion. Station 03 exceeded the criterion 36 percent of the time while station 04 never exceeded it.

From Silver Bow Creek station 04, downstream into the mainstem Clark Fork, a steady increase is noted in sediment concentration and frequency of exceedence of the criterion. The worst case location, in terms of suspended sediment severity, occurred at station 10, above the Little Blackfoot River. This coincided with the worst case locations for both metals and nutrients severity. The presence of streamside tailings deposits and unstable streambanks no doubt contribute to the problems documented.

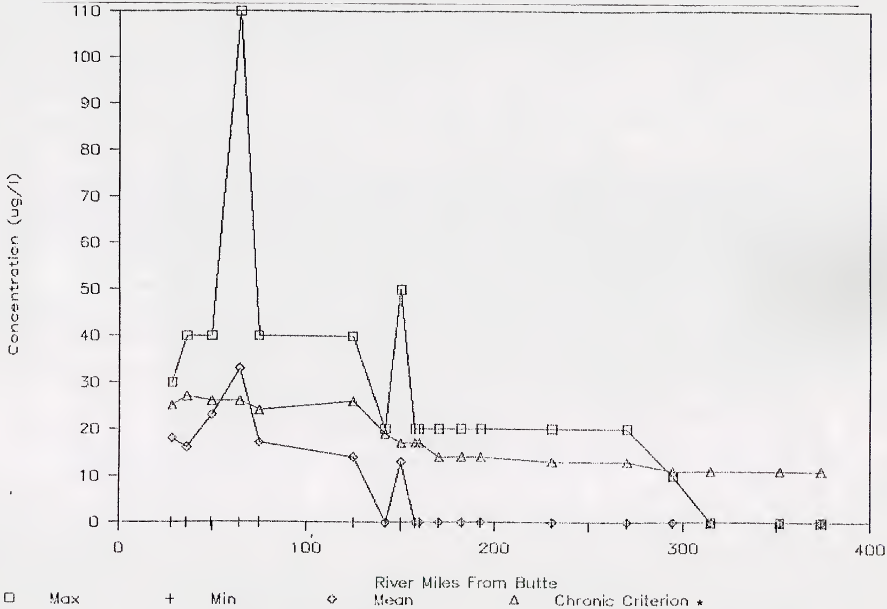
The Bonita station (12) at river mile 124 fell out as a location of significant sediment problems, and this seemed

apparent during field monitoring activities. Further downstream, the inflows of Rock Creek and the Bitterroot River significantly reduced sediment severity scores. Milltown Dam had a negative effect and caused a temporary spike in sediment severity scores. As with metals concentrations, this temporary increase in sediment was probably attributable to the reconstruction of the Milltown Dam spillway in 1986.

Frequency of exceedence of the sediment criterion and sediment severity scores declined from below Milltown Dam to the Idaho border, with very low scores at stations 29 and 30 (below Noxon Rapids and Cabinet Gorge Dams, respectively.).

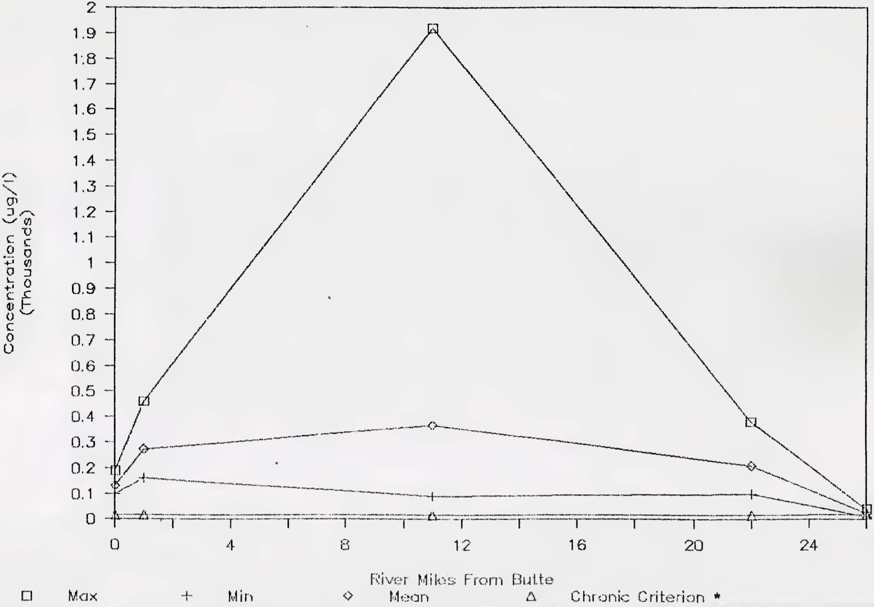
Figures 60 - 62 present suspended sediment concentrations, frequency of exceedence of the criterion and severity scores for tributaries and wastewater discharges to the Clark Fork. Only station 21, the Stone Container Corporation wastewater discharge, stands out as containing significant concentrations of suspended sediment. That discharge was the subject of a recent Environmental Impact Statement and it is governed by a stringent discharge permit. The computed annual suspended solids loading rates for FY 1987 were within allowable limits specified in the permit.

Figure 2. Maximum, minimum and annual mean total recoverable copper concentrations by stream mile in the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



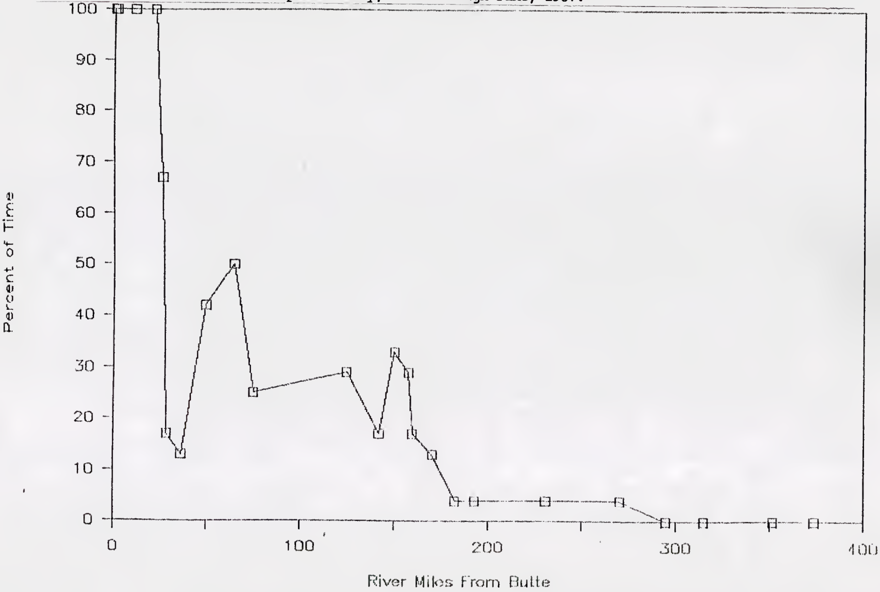
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 3. Maximum, minimum and annual mean total recoverable copper concentrations by stream mile in Silver Bow Creek from Butte, MT to below the Warm Springs treatment ponds for the period July, 1986 through June, 1987.



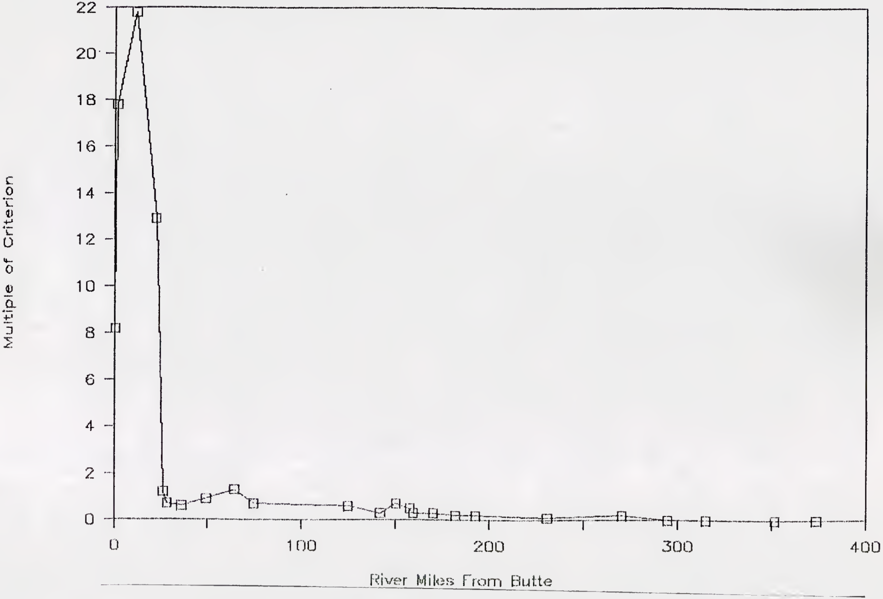
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 4. Frequency of total recoverable copper measurements by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID exceeding the EPA chronic criterion for the protection of freshwater aquatic life* for the period July, 1986 through June, 1987.



* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 5. Annual average magnitude of exceedence of the EPA copper chronic criterion for the protection of freshwater aquatic life* by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440 5-86-001, May, 1986.

Figure 6. Copper severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

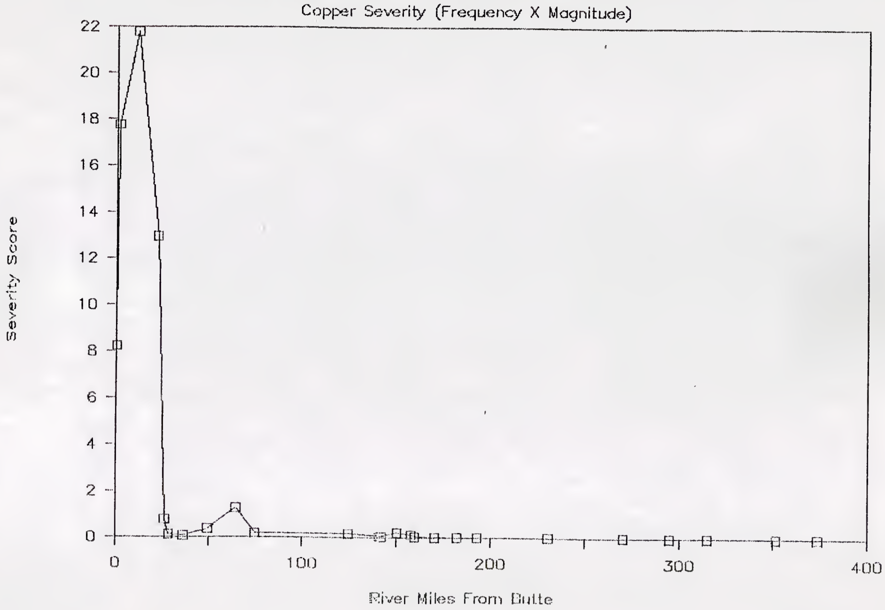


Figure 7. Copper severity scores (expanded scale) by stream mile for the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for FY 1987.

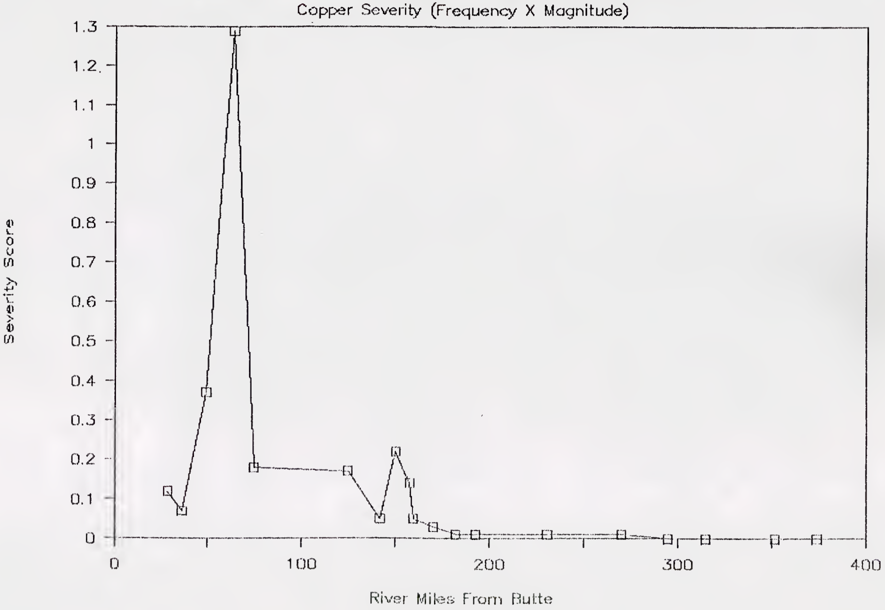
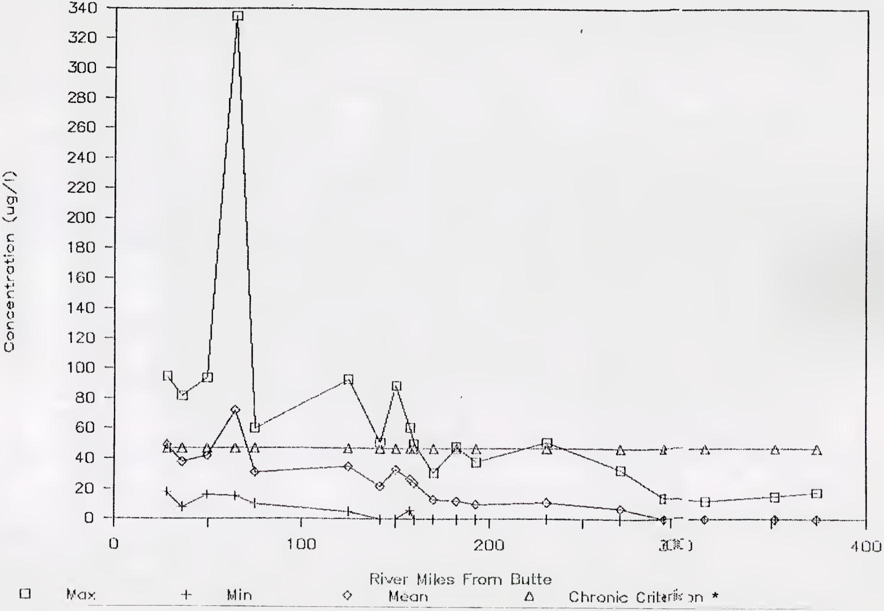
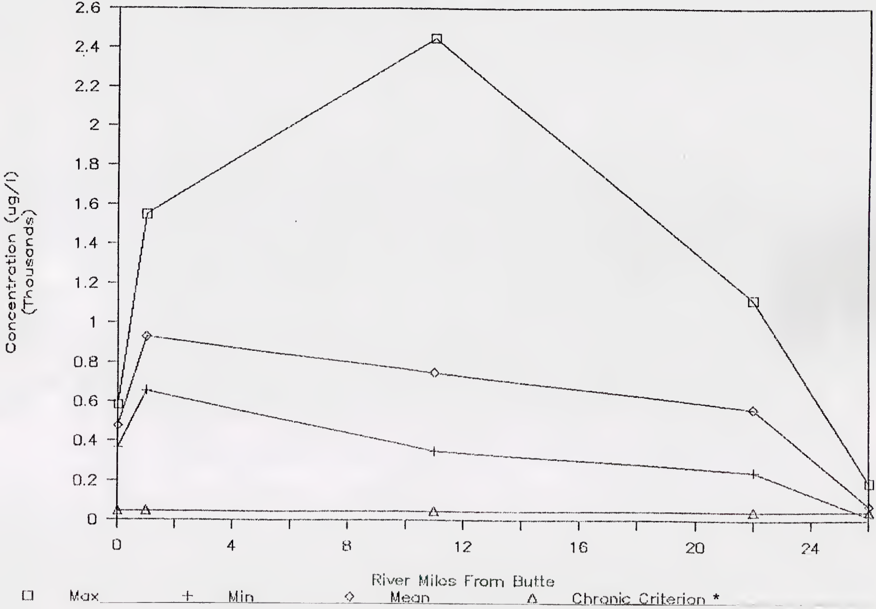


Figure 8. Maximum, minimum and annual mean total recoverable zinc concentrations by stream mile in the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



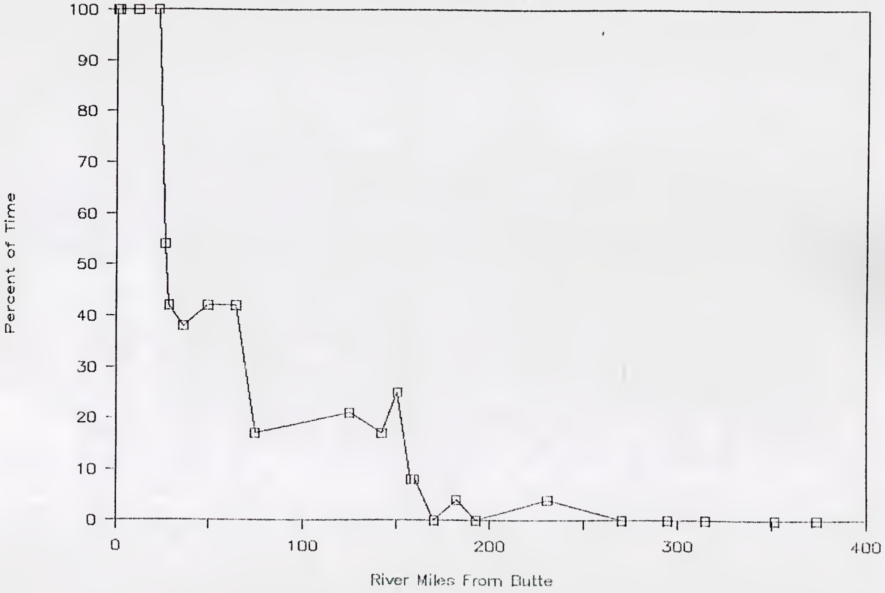
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 9. Maximum, minimum and annual mean total recoverable zinc concentrations by stream mile in Silver Bow Creek from Butte, MT to below the Warm Springs treatment ponds for the period July, 1986 through June, 1987.



* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 10. Frequency of total recoverable zinc measurements by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID exceeding the EPA chronic criterion for the protection of freshwater aquatic life* for the period July, 1986 through June, 1987.



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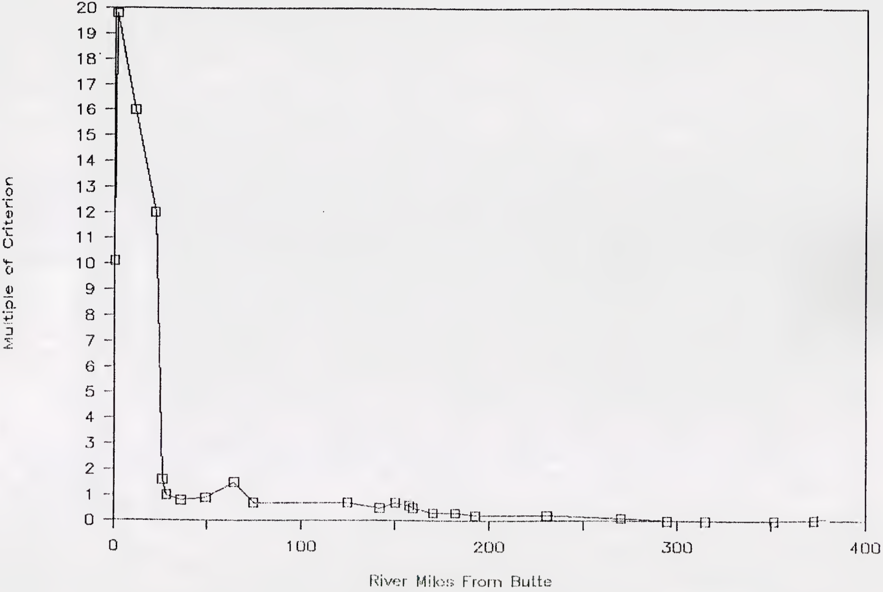
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 11. Annual average magnitude of exceedence of the EPA zinc chronic criterion for the protection of freshwater aquatic life* by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



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* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 12. Zinc severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

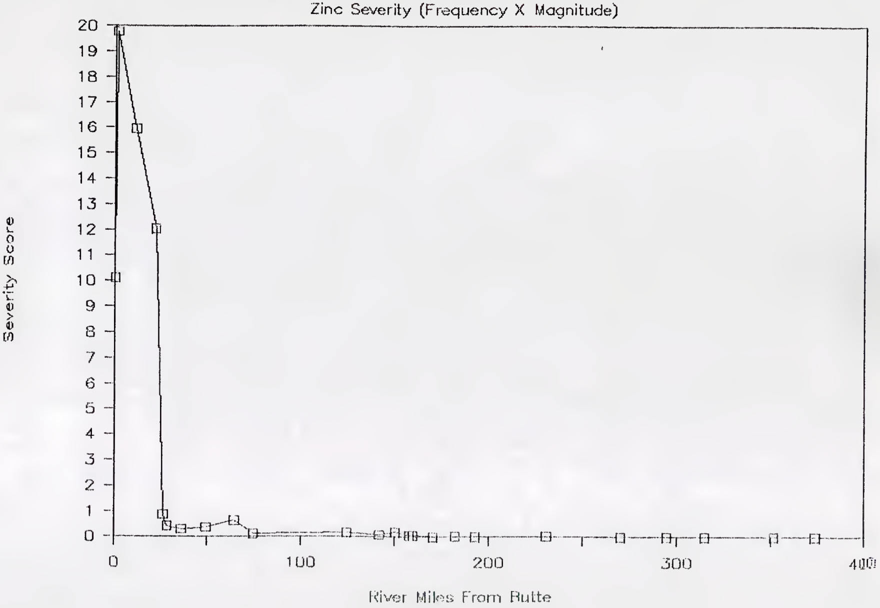


Figure 13. Zinc severity scores (expanded scale) by stream mile for the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for FY 1987.

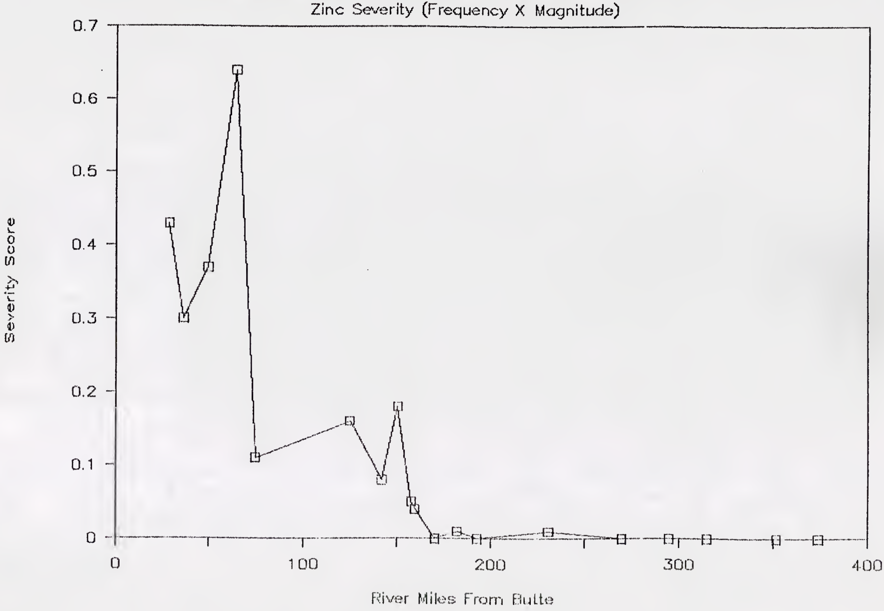
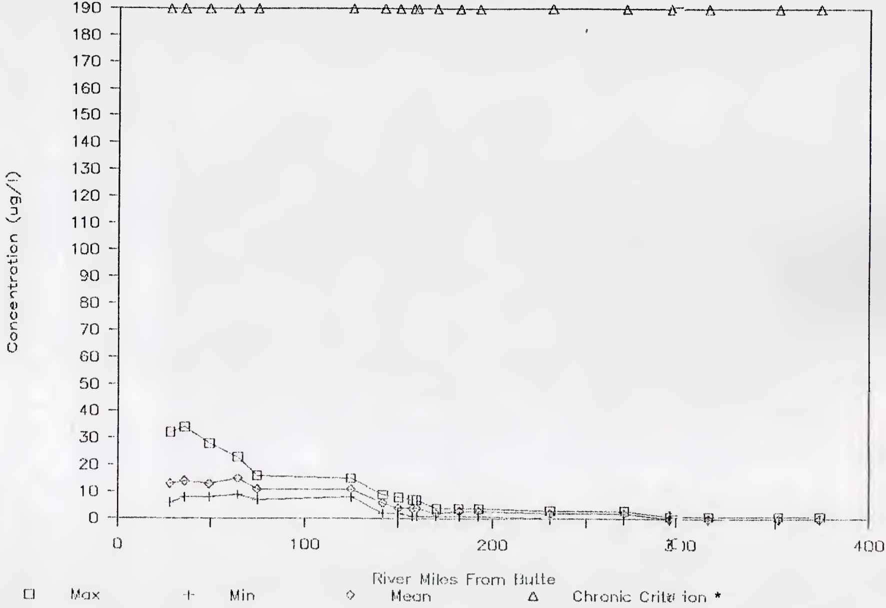


Figure 14. Maximum, minimum and annual mean total recoverable arsenic concentrations by stream mile in the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for the period of July, 1986 through June, 1987.



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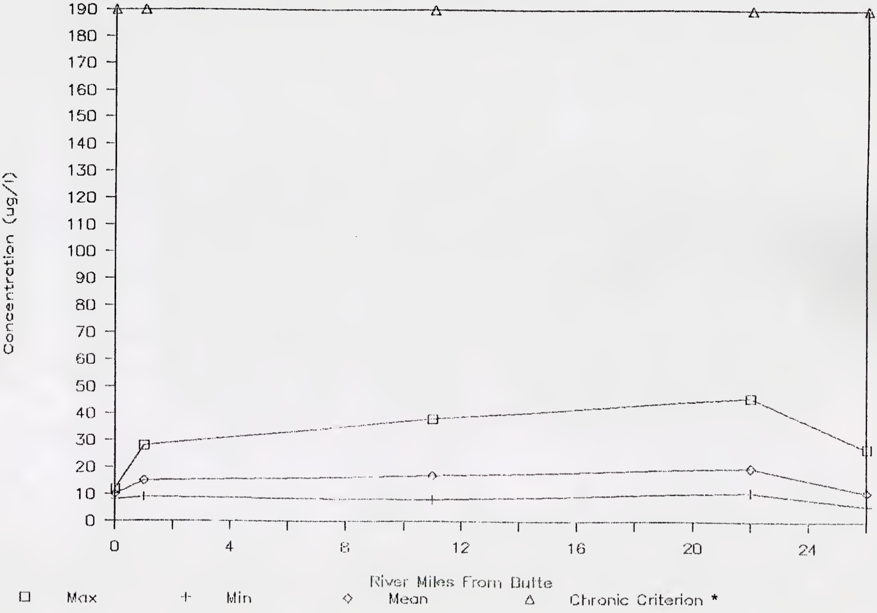
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 15. Maximum, minimum and annual mean total recoverable arsenic concentrations by stream mile in Silver Bow Creek from Butte, MT to below the Warm Springs treatment ponds for the period July, 1986 through June, 1987.



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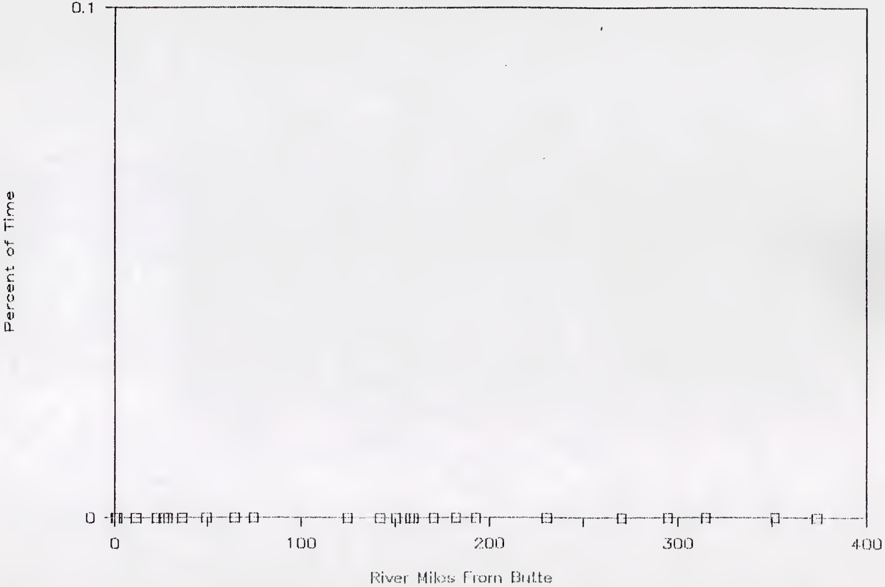
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 16. Frequency of total recoverable arsenic measurements by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinent Gorge Dam, ID exceeding the EPA chronic criterion for the protection of freshwater aquatic life* for the period July, 1986 through June, 1987.



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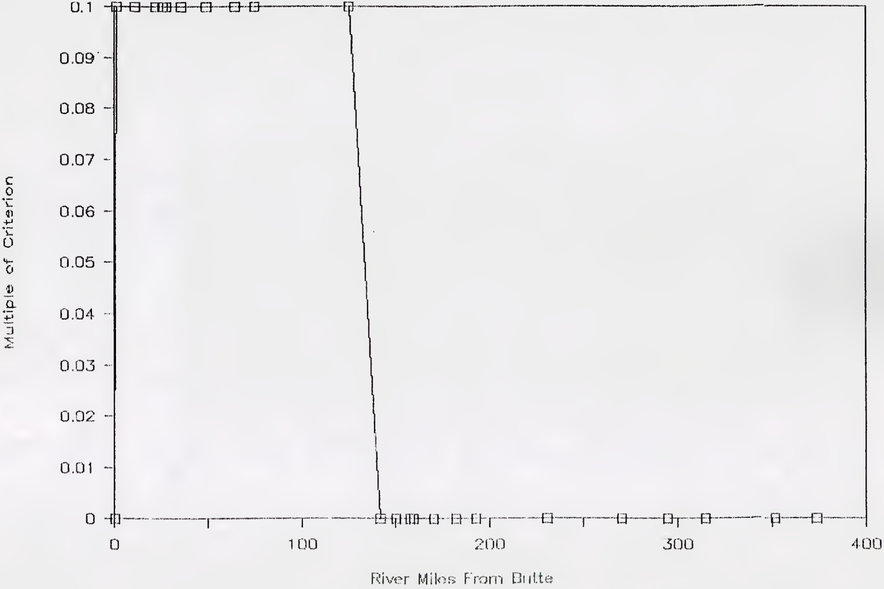
* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 17. Annual average magnitude of exceedence of the EPA arsenic chronic criterion for the protection of freshwater aquatic life* by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



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* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 18. Arsenic severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

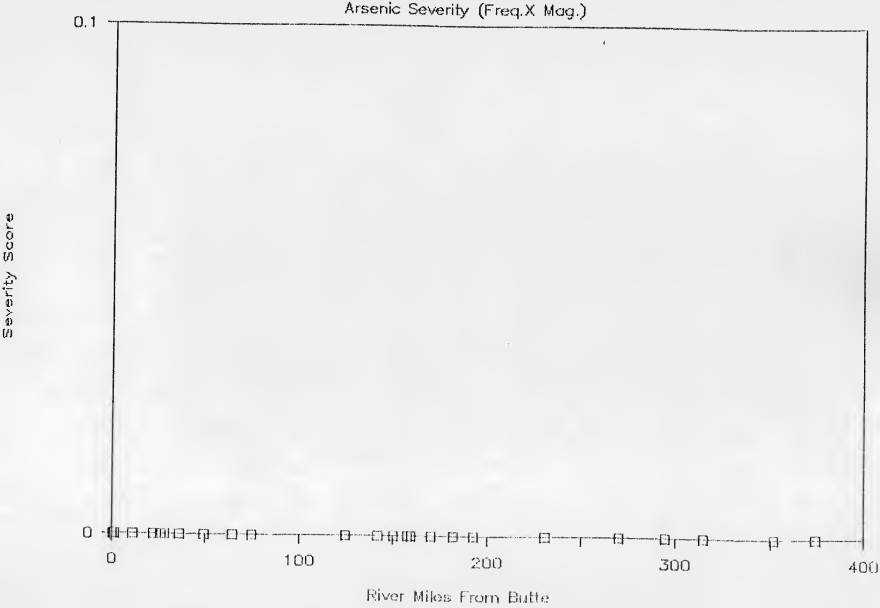


Figure 19. Cumulative metals severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

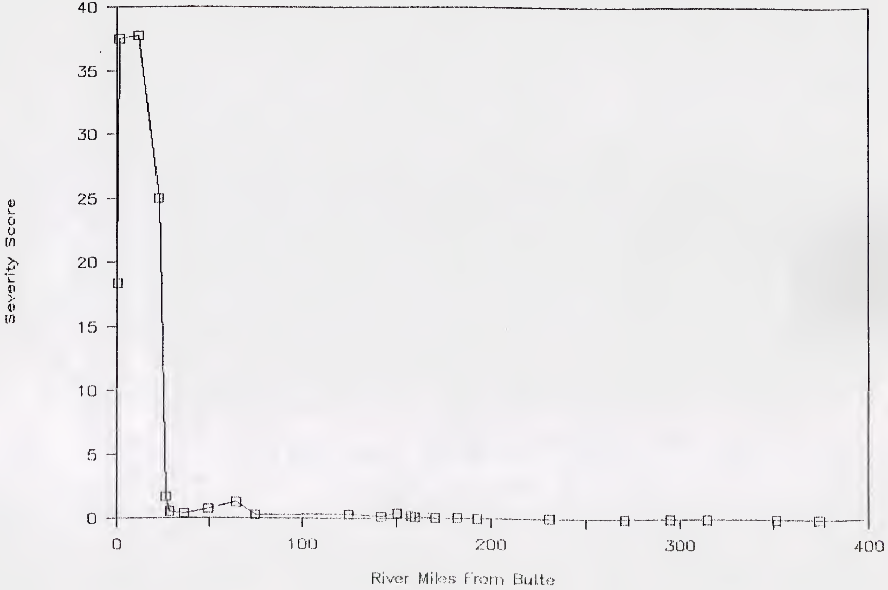


Figure 20. Cumulative metals severity scores (expanded scale) by stream mile for the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for FY 1987.

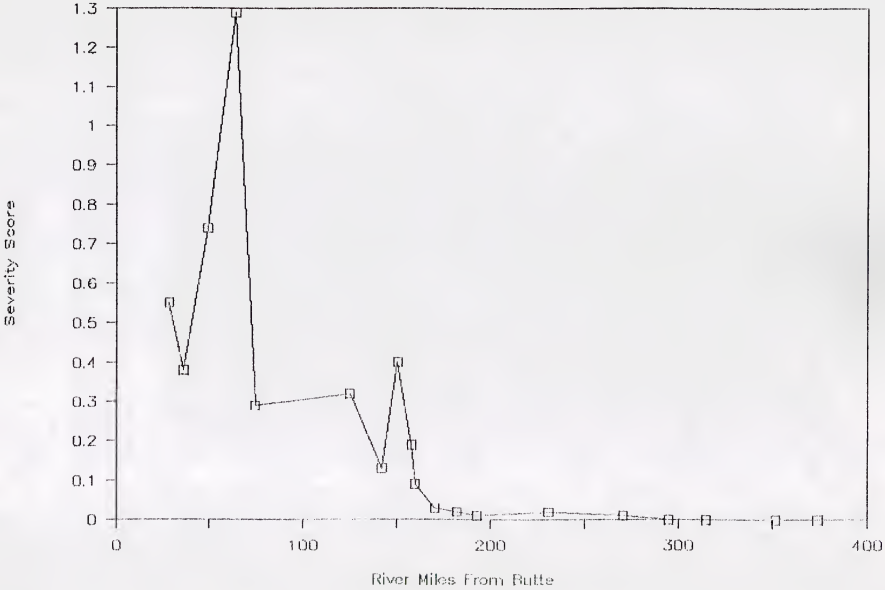


Figure 21. Maximum, annual mean and minimum total recoverable copper concentrations in tributaries and municipal and industrial wastewater discharges to the Clark Fork River for the period July, 1986 through June, 1987.

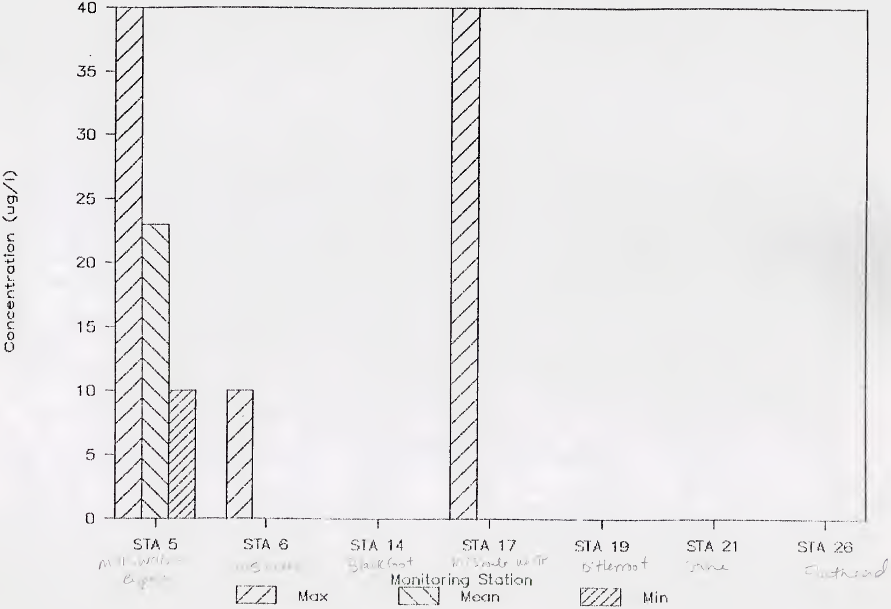


Figure 22. Maximum, annual mean and minimum total recoverable zinc concentrations in tributaries and municipal and industrial wastewater discharges to the Clark Fork River for the period July, 1986 through June, 1987.

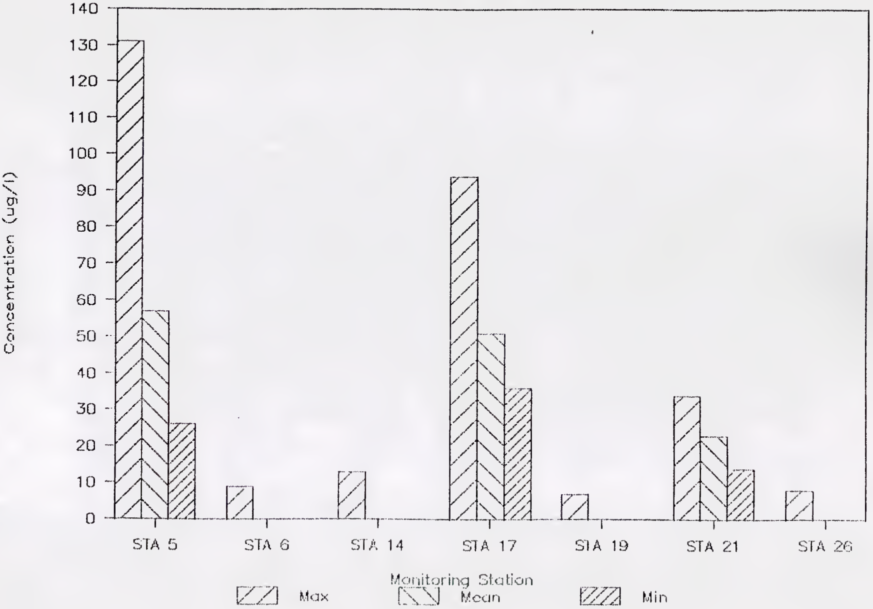


Figure 23. Maximum, annual mean and minimum total recoverable arsenic concentrations in tributaries and municipal and industrial wastewater discharges to the Clark Fork River for the period July, 1986 through June, 1987.

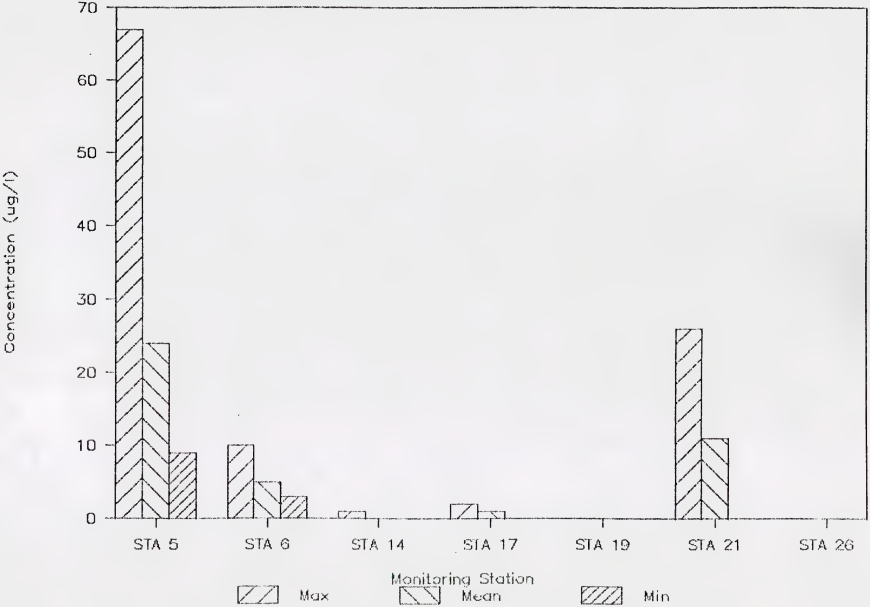
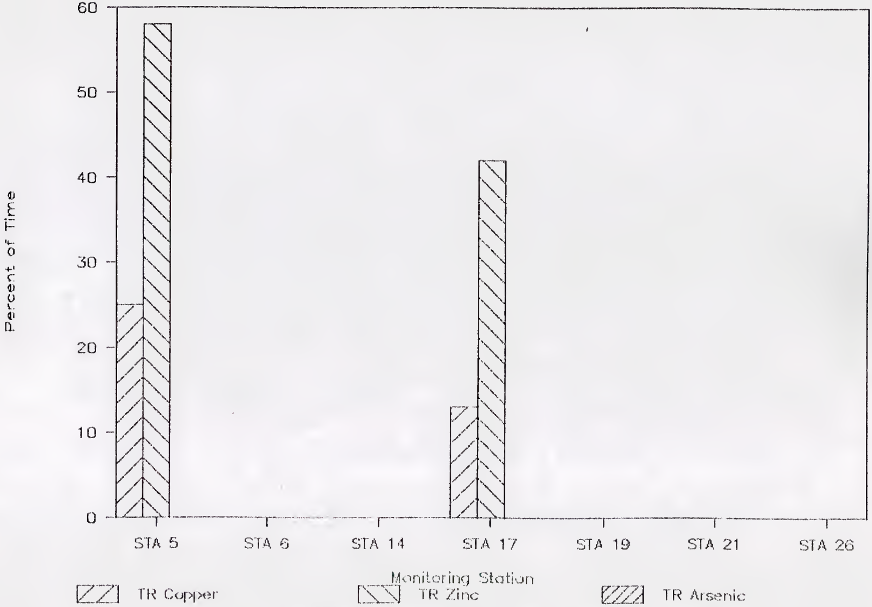


Figure 24. Frequency of total recoverable copper, zinc and arsenic measurements in tributaries and municipal and industrial wastewater discharges to the Clark Fork River exceeding the EPA chronic criteria for the protection of freshwater aquatic life* for the period July, 1986 through June, 1986.



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* 24-hour average concentration that should not be exceeded in order to protect freshwater aquatic life. EPA 440/5-86-001, May, 1986.

Figure 25. Copper, zinc and arsenic severity scores for tributaries and municipal and industrial wastewater discharges to the Clark Fork River for FY 1987.

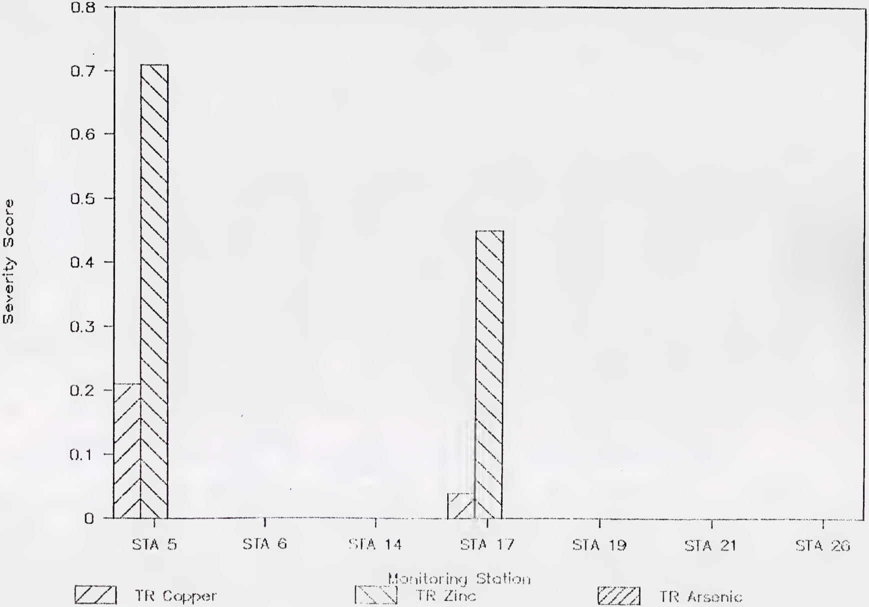


Figure 26. Time series plot of total recoverable copper concentration and streamflow for monitoring station 01, Silver Bow Creek below the Colorado Tailings, for FY 1987.

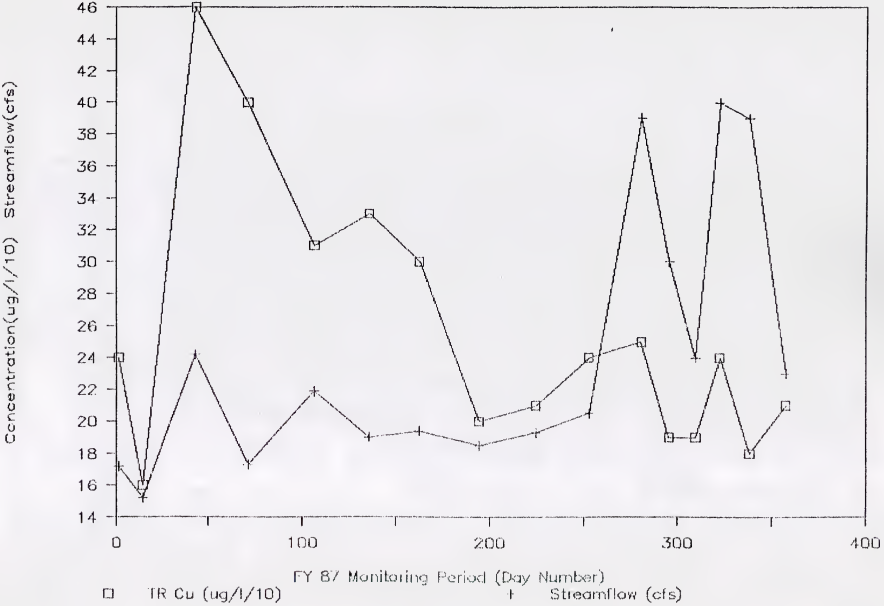


Figure 27. Time series plot of total recoverable copper concentration and streamflow for monitoring station 04, Warm Springs Pond 2 discharge (Silver Bow Creek), for FY 1987.

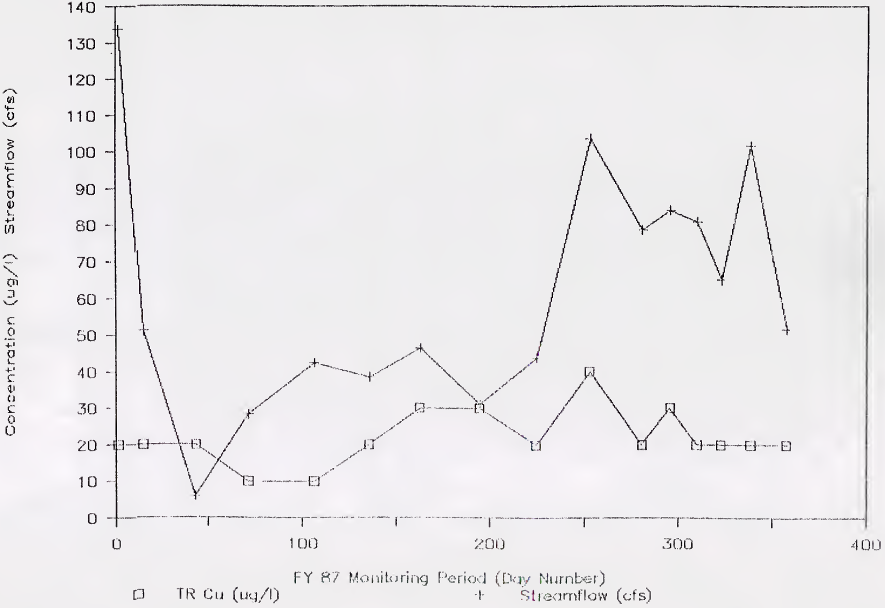


Figure 28. Time series plot of total recoverable copper concentration and streamflow for monitoring station 07, Clark Fork River below Warm Springs Creek, for FY 1987.

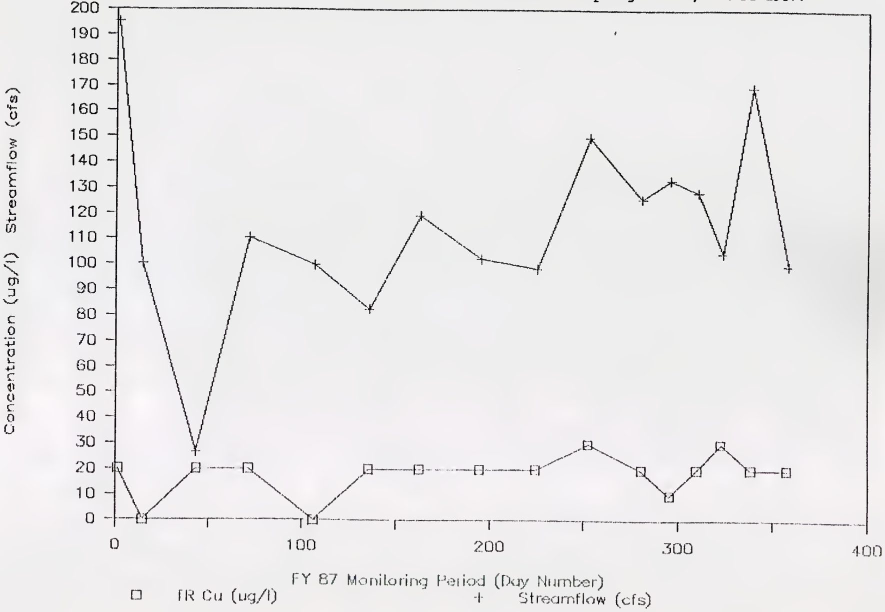


Figure 29. Time series plot of total recoverable copper concentration and streamflow for monitoring station 10, Clark Fork River above Little Blackfoot River, for FY 1987.

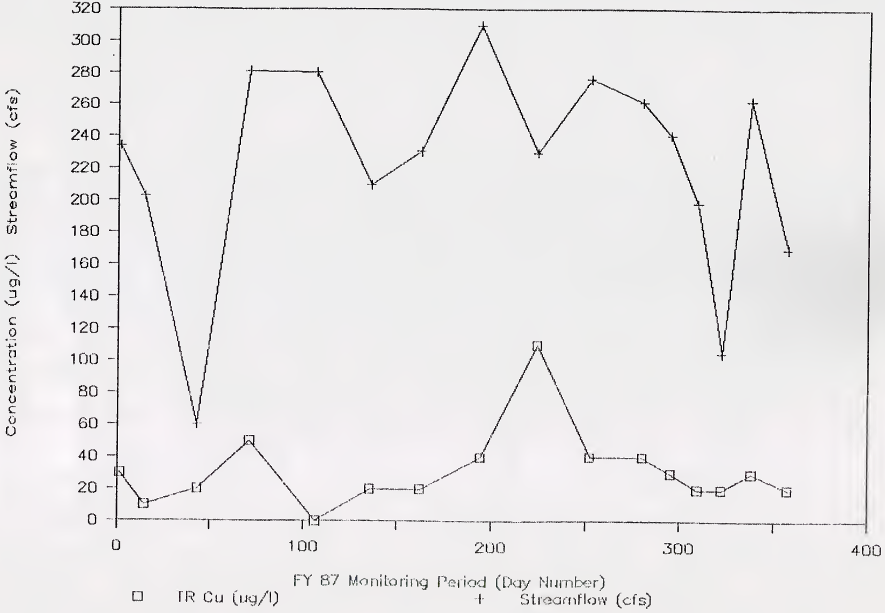
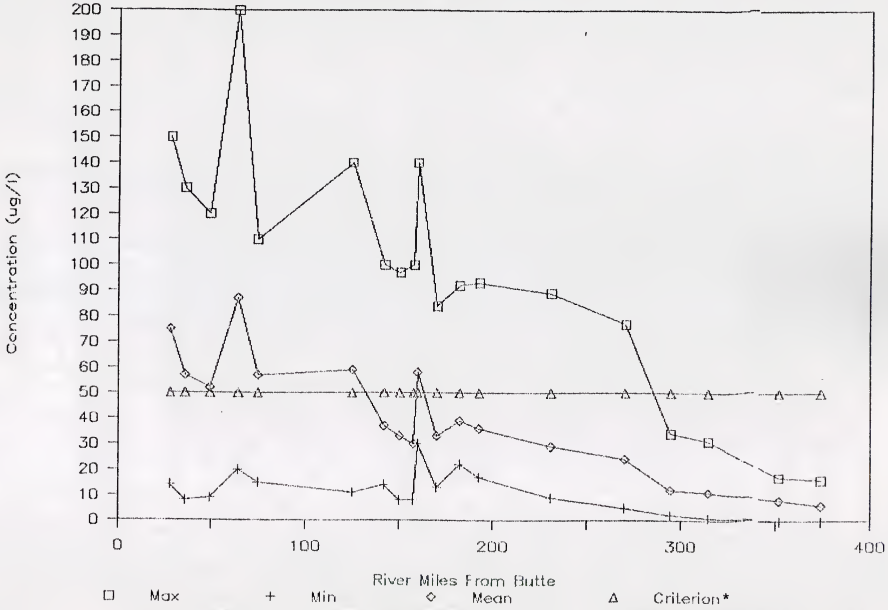
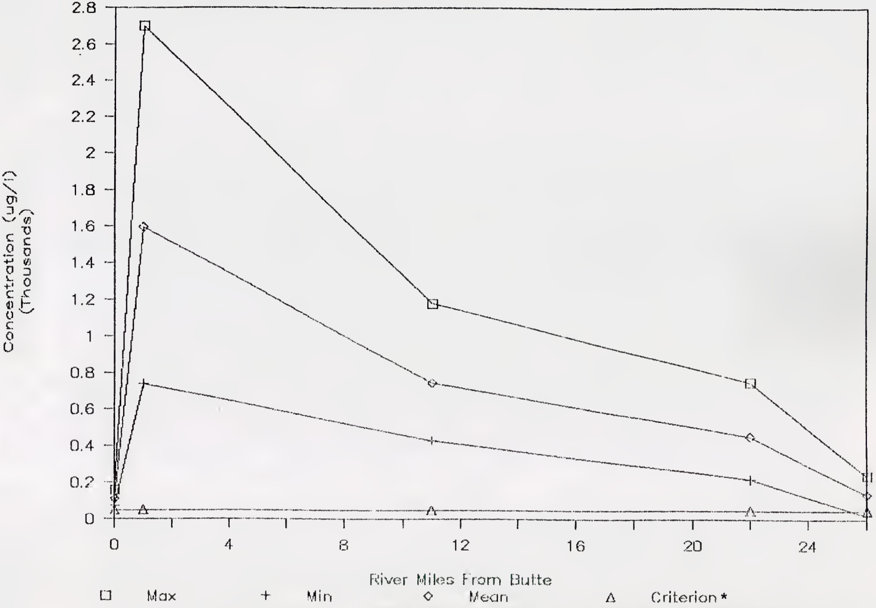


Figure 30. Maximum, minimum and annual mean total phosphorus concentrations by stream mile in the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



* Concentration that should not be exceeded in streams entering lakes or reservoirs in order to prevent the development of biological nuisances and to control accelerated or cultural eutrophication. EPA 440/5-86-001, May, 1986.

Figure 31. Maximum, minimum and annual mean total phosphorus concentrations by stream mile in Silver Bow Creek from Butte, MT to below the Warm Springs treatment ponds for the period July, 1986 through June, 1987.



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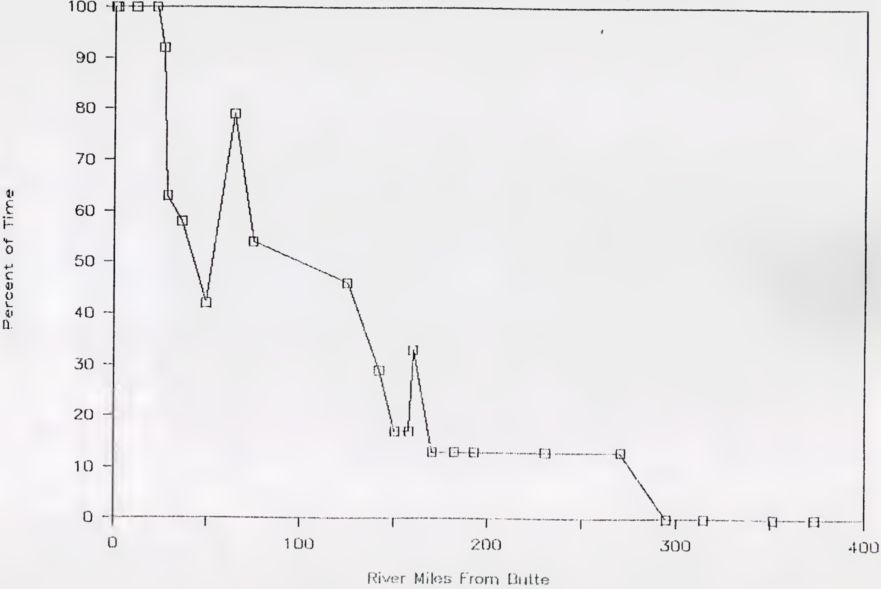
* Concentration that should not be exceeded in streams entering lakes or reservoirs in order to prevent the development of biological nuisances and to control accelerated or cultural eutrophication. EPA 440/5-86-001, May, 1986.

Figure 32. Frequency of total phosphorus measurements by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID exceeding the EPA criterion to prevent the development of biological nuisances and to control cultural eutrophication* for the period July, 1986 through June, 1987.



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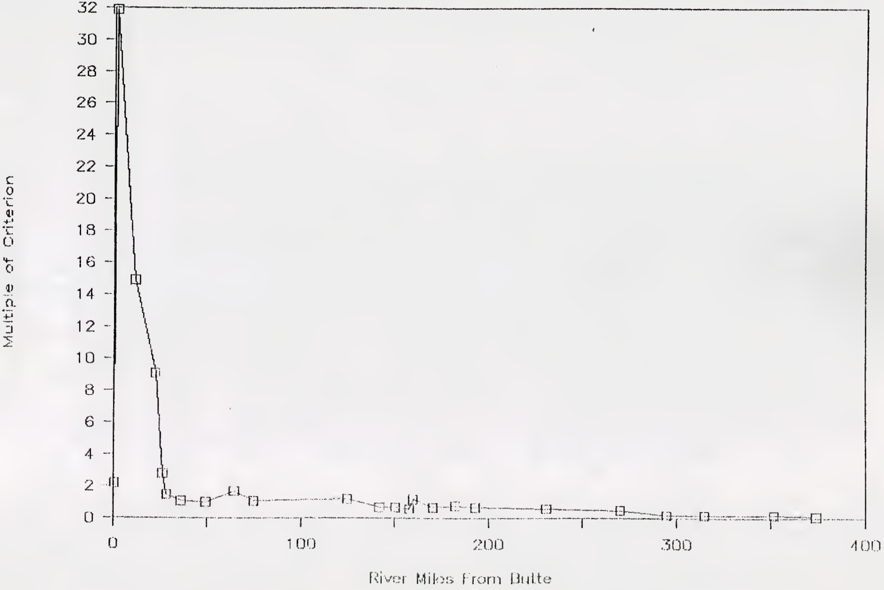
* Concentration that should not be exceeded in streams entering lakes or reservoirs. EPA 440/5-86-001, May, 1986.

Figure 33. Annual average magnitude of exceedence of the EPA total phosphorus criterion to prevent the development of biological nuisances and to control cultural eutrophication* by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



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* Concentration that should not be exceeded in streams entering lakes or reservoirs. EPA 440/5-86-001, May, 1986.

Figure 34. Total phosphorus severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

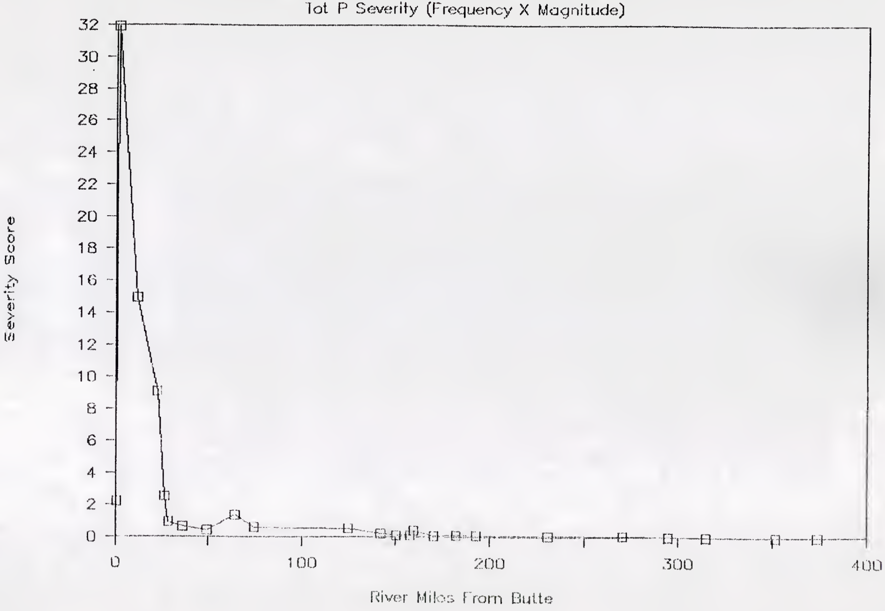


Figure 35. Total phosphorus severity scores (expanded scale) by stream mile for the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for FY 1987.

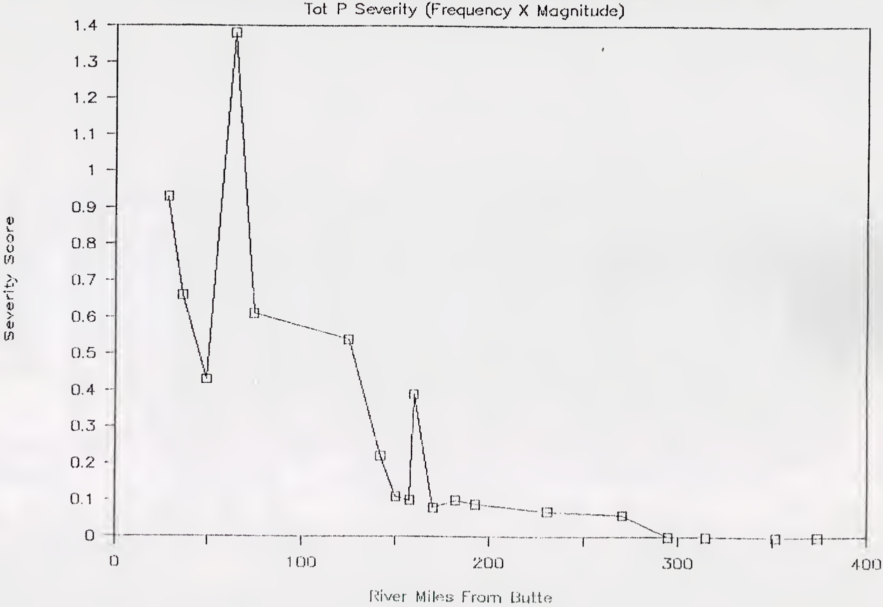
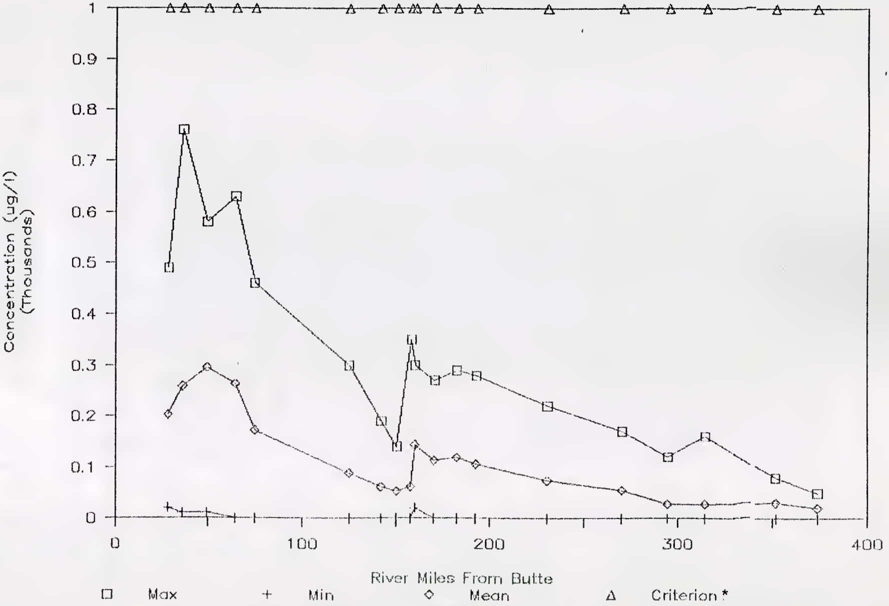


Figure 36. Maximum, minimum and annual mean total soluble inorganic nitrogen concentrations by stream mile in the Clark Fork River from Warm Springs, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



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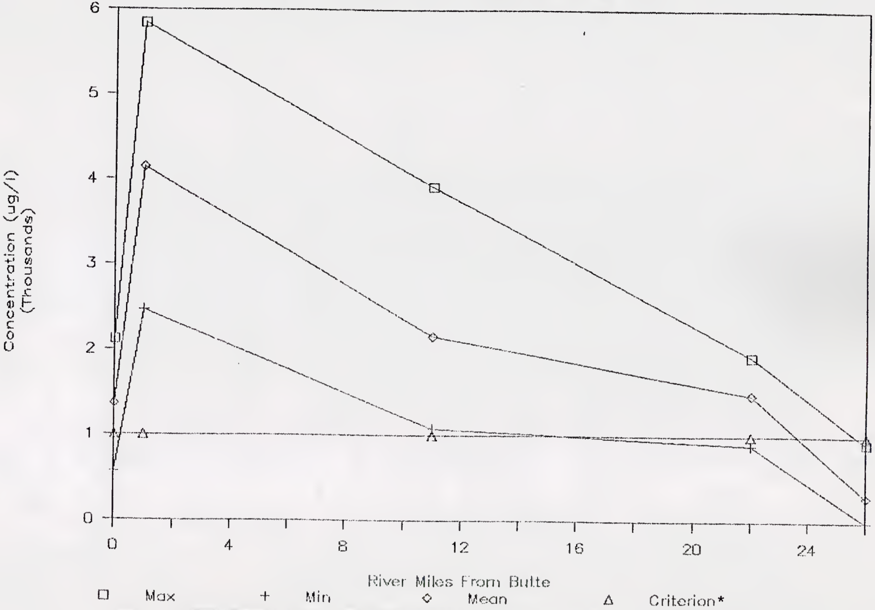
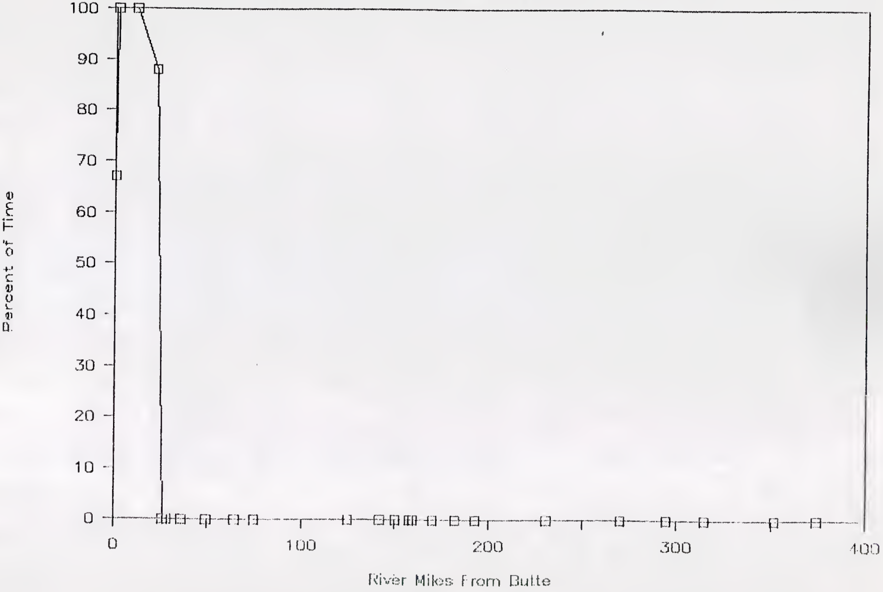
* Concentration that should not be exceeded in streams in order to prevent the development of nuisance algae. Water quality criteria matrix in MDHES. 1986. Montana Water Quality -- The 1986 Montana 305(b) Report, May 1986.

Figure 37. Maximum, minimum and annual mean total soluble inorganic nitrogen concentrations by stream mile in Silver Bow Creek from Butte, MT to below the Warm Springs Treatment Ponds for the period July, 1986 through June, 1987.



* Concentration that should not be exceeded in streams in order to prevent the deveopment of nuisance algae. Water quality criteria matrix in MDHES. 1986. Montana Water Quality -- The 1986 Montana 305(b) Report, May 1986.

Figure 38. Frequency of total soluble inorganic nitrogen measurements by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID exceeding the MDHES criterion to prevent the development of nuisance algae* for the period July, 1986 through June, 1987.



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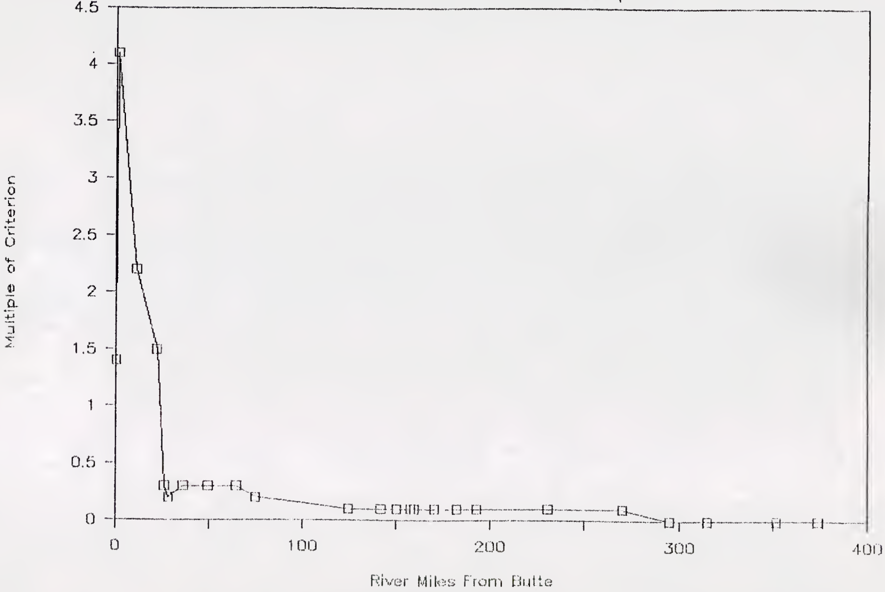
* Concentration that should not be exceeded in streams. Water quality criteria matrix in MDHES. 1986. Montana Water Quality -- The Montana 306(b) Report, May, 1986.

Figure 39. Annual average magnitude of exceedence of the MDHES total soluble inorganic nitrogen criterion to prevent the development of nuisance algae* by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



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* Concentration that should not be exceeded in streams. Water quality criteria matrix in MDHES. 1986. Montana Water Quality -- The Montana 306(b) Report, May, 1986.

Figure 40. Total soluble inorganic nitrogen severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

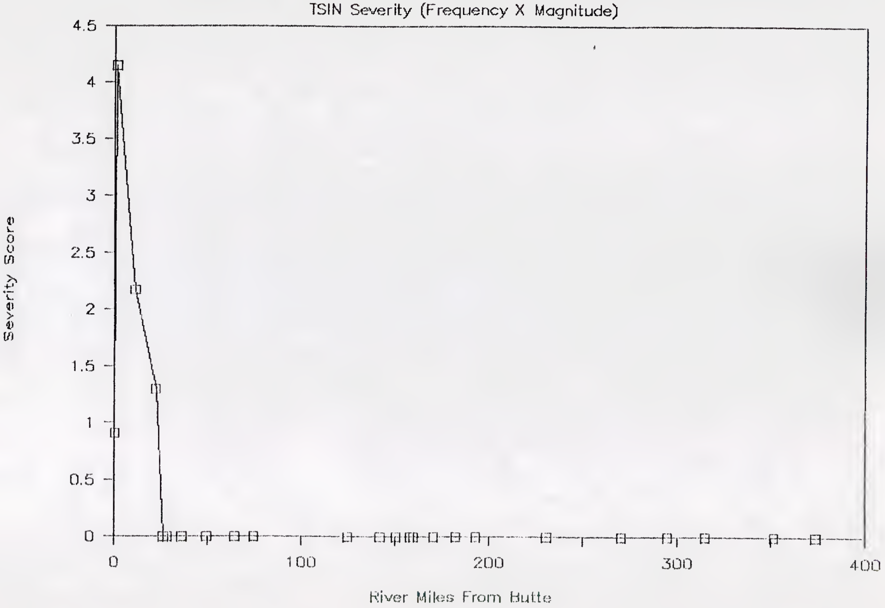
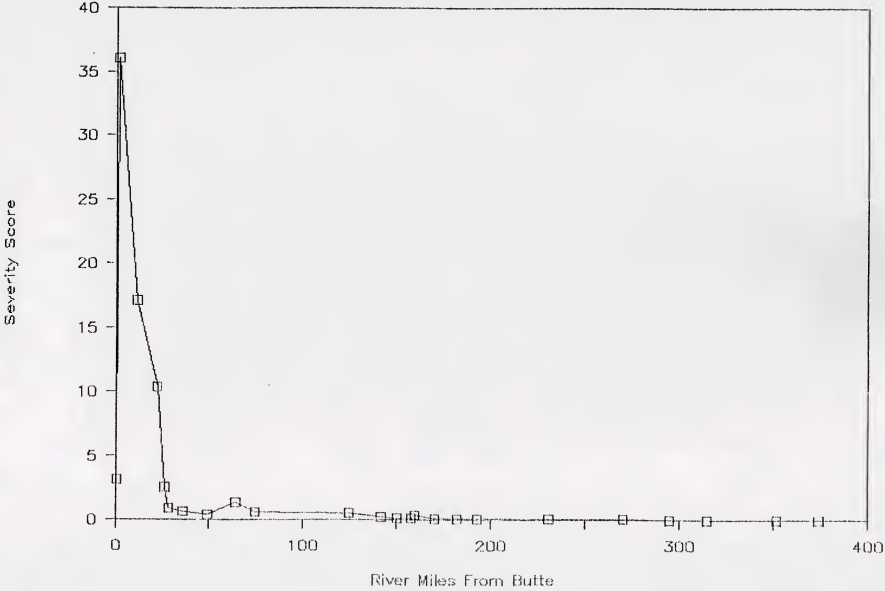


Figure 41. Cumulative nutrients severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.



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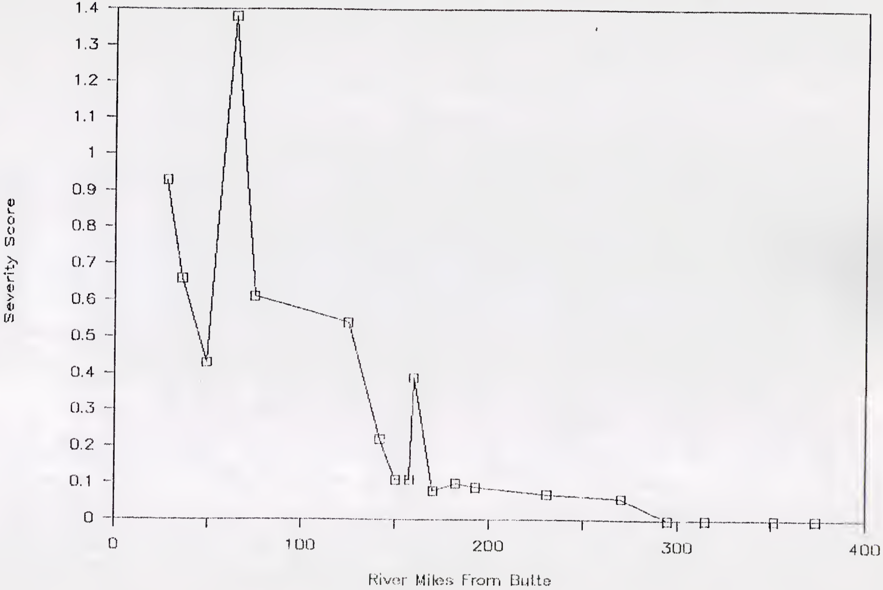


Figure 43. Maximum, annual mean and minimum total phosphorus concentrations in tributaries to the Clark Fork River for the period July, 1986 through June, 1987.

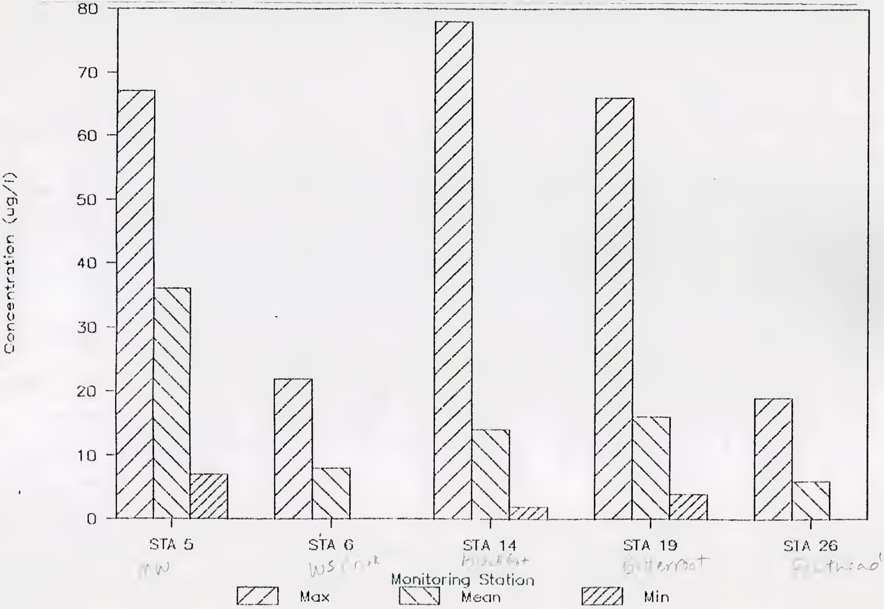


Figure 44. Maximum, annual mean and minimum total phosphorus concentrations in municipal and industrial wastewater discharges to the Clark Fork River for the period July, 1986 through June, 1987.

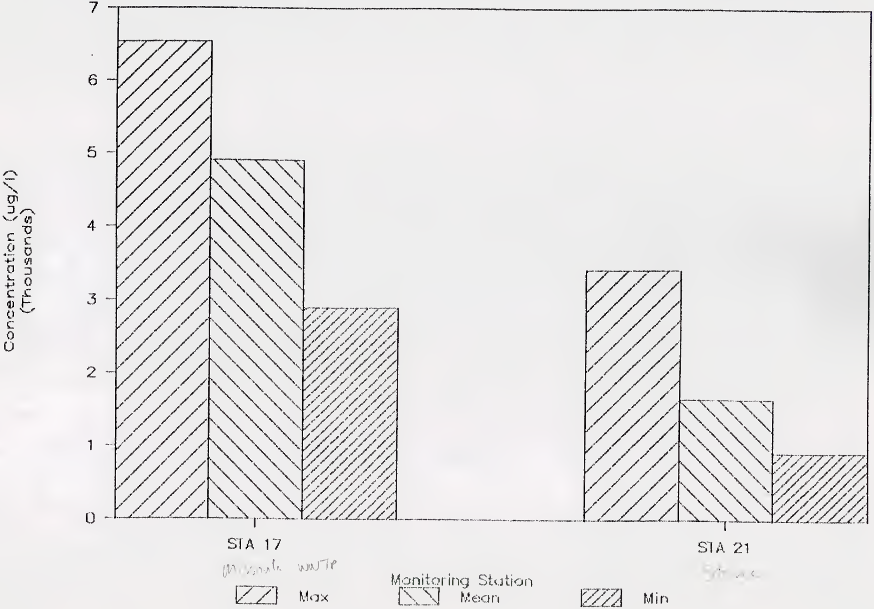


Figure 45. Maximum, annual mean and minimum total soluble inorganic nitrogen concentrations in tributaries to the Clark Fork River for the period July, 1986 through June, 1987.

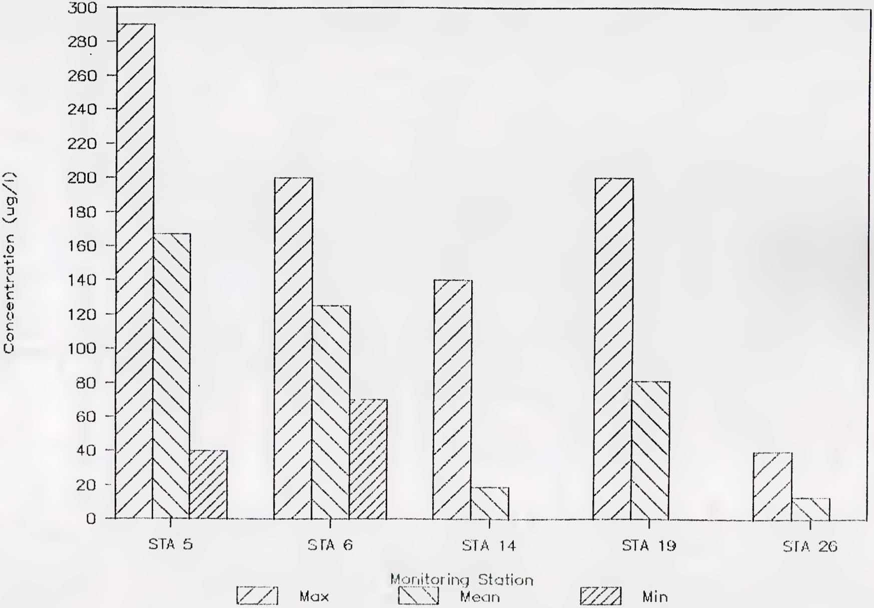


Figure 46. Maximum, annual mean and minimum total soluble inorganic nitrogen concentrations in municipal and industrial wastewater discharges to the Clark Fork River for the period July, 1986 through June, 1987.

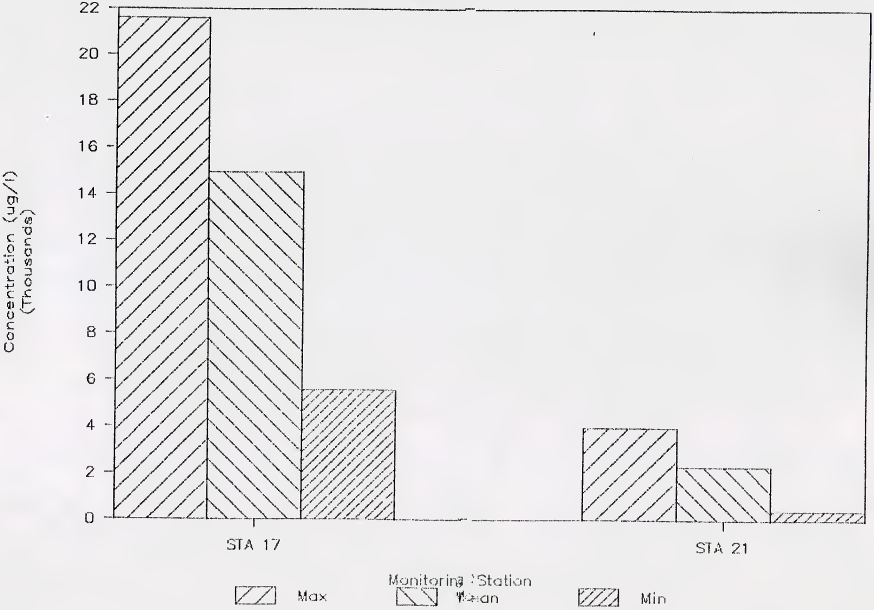
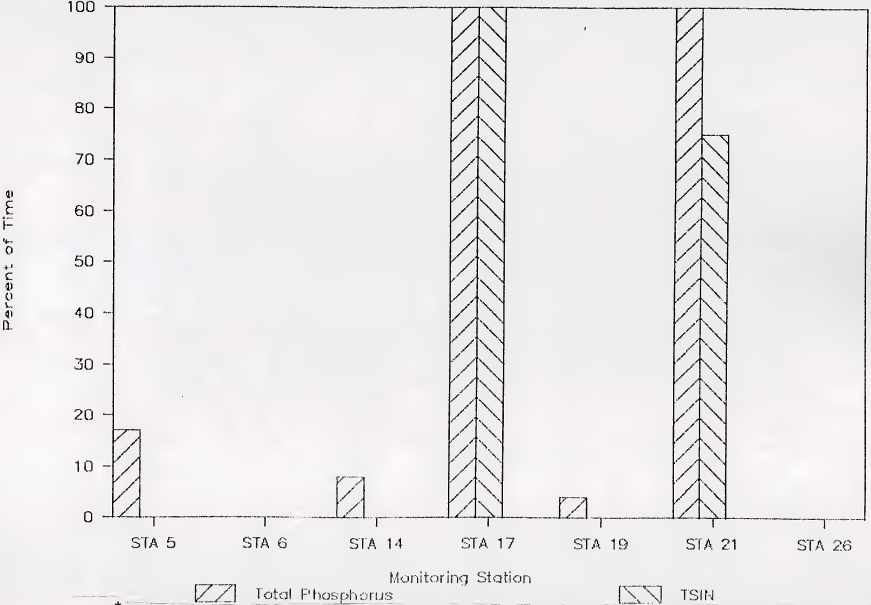


Figure 47. Frequency of total phosphorus and total soluble inorganic nitrogen measurements in tributaries and municipal and industrial wastewater discharges to the Clark Fork River exceeding criteria for the prevention of biological nuisances and to control cultural eutrophication* for the period July, 1986 through June, 1986.



* Phosphorus concentration that should not be exceeded in streams entering lakes or reservoirs in order to prevent the development of biological nuisances and to control accelerated or cultural eutrophication. EPA 440/5-86-001, May, 1986; Nitrogen concentration that should not be exceeded in streams in order to prevent the deveopment of nuisance algae. Water quality criteria matrix in MDHES. 1986. Montana Water Quality -- The 1986 Montana 305(b) Report, May 1986.

Figure 48. Total phosphorus and total soluble inorganic nitrogen severity scores for tributaries and municipal and industrial wastewater discharges to the Clark Fork River for FY 1987.

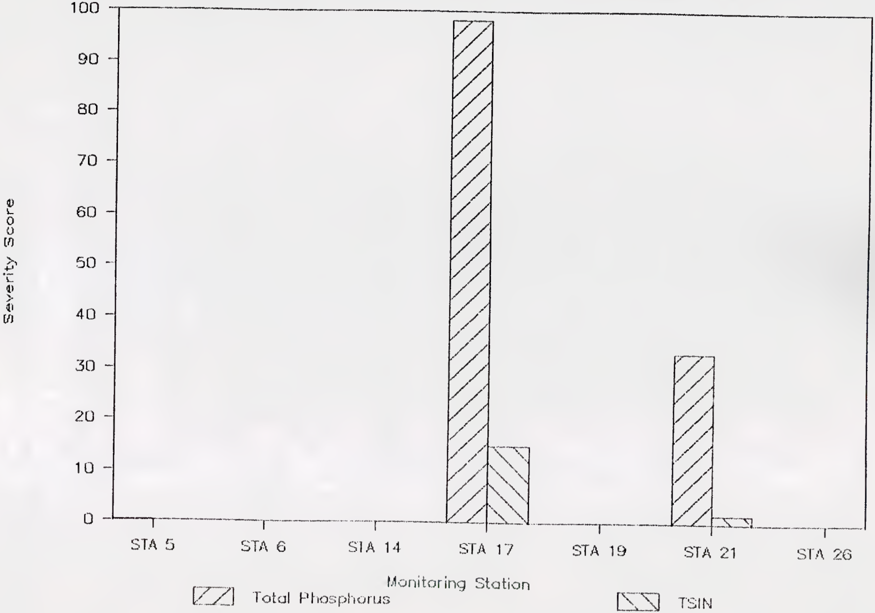
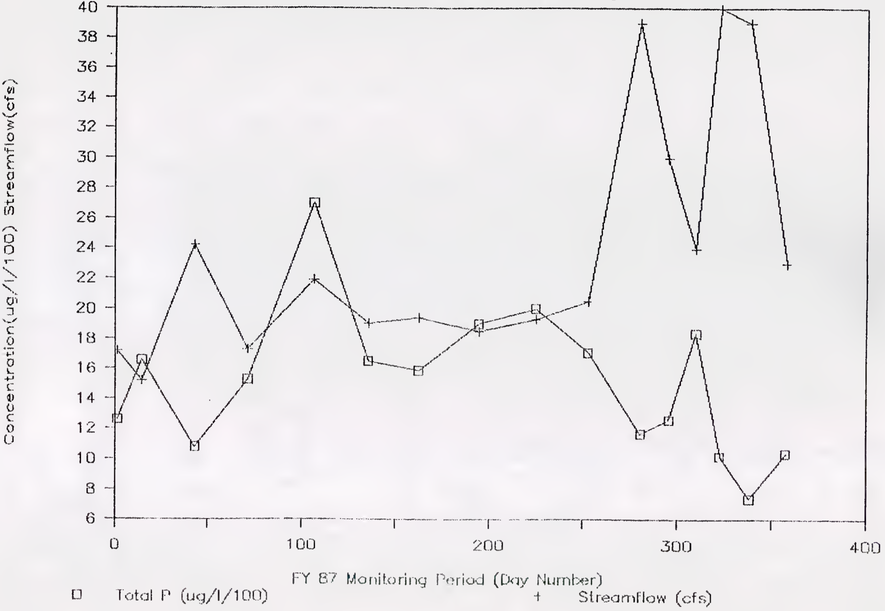


Figure 49. Time series plot of total phosphorus concentration and streamflow for monitoring station 01, Silver Bow Creek below the Colorado Tailings, for FY 1987.



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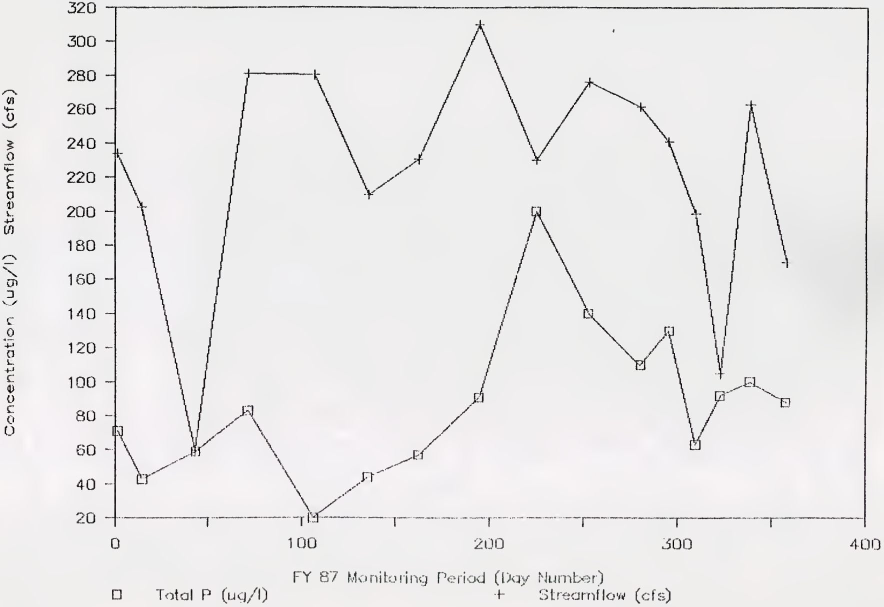

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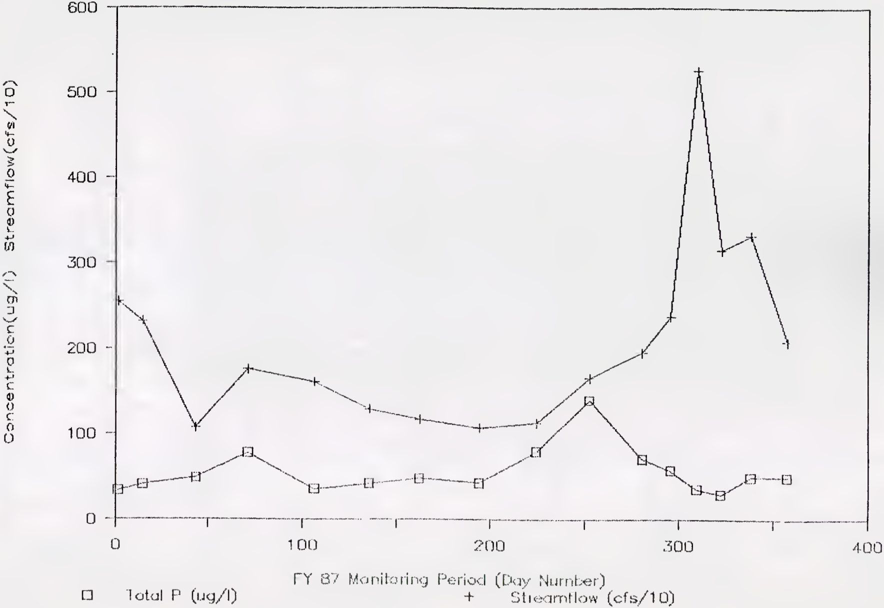
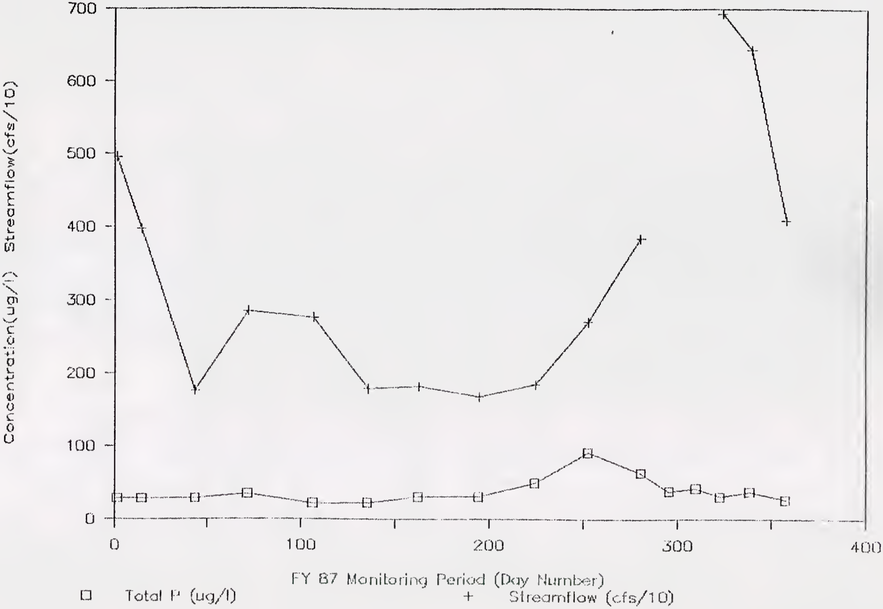


Figure 52. Time series plot of total phosphorus concentration and streamflow for monitoring station 22, Clark Fork River at Huson, for FY 1987.



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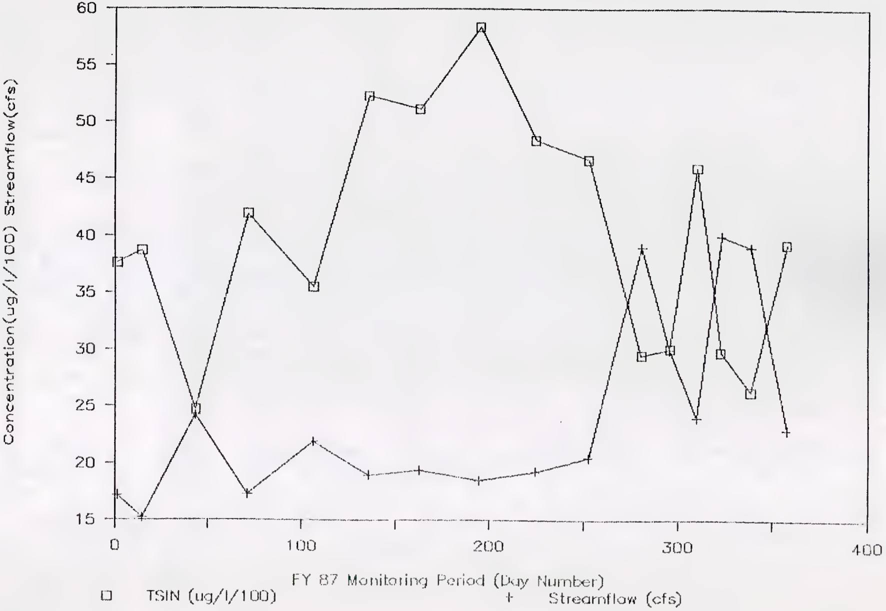
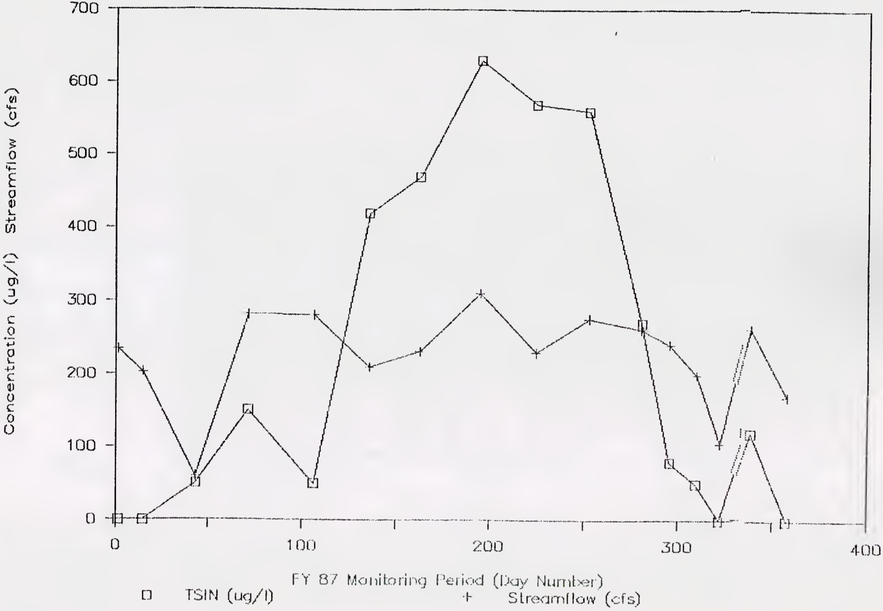


Figure 54. Time series plot of total soluble inorganic nitrogen concentration and streamflow for monitoring station 10, Clark Fork River above Little Blackfoot River, for FY 1987.



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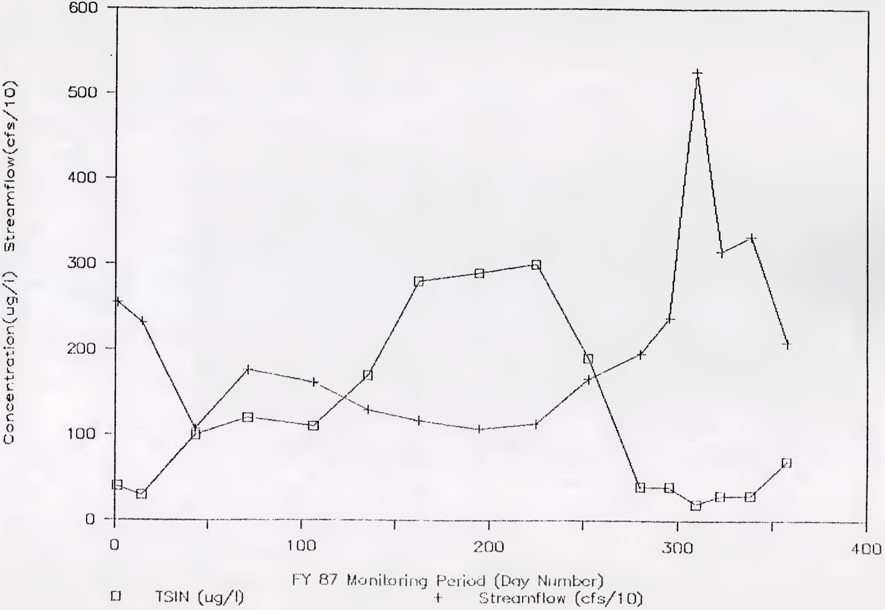

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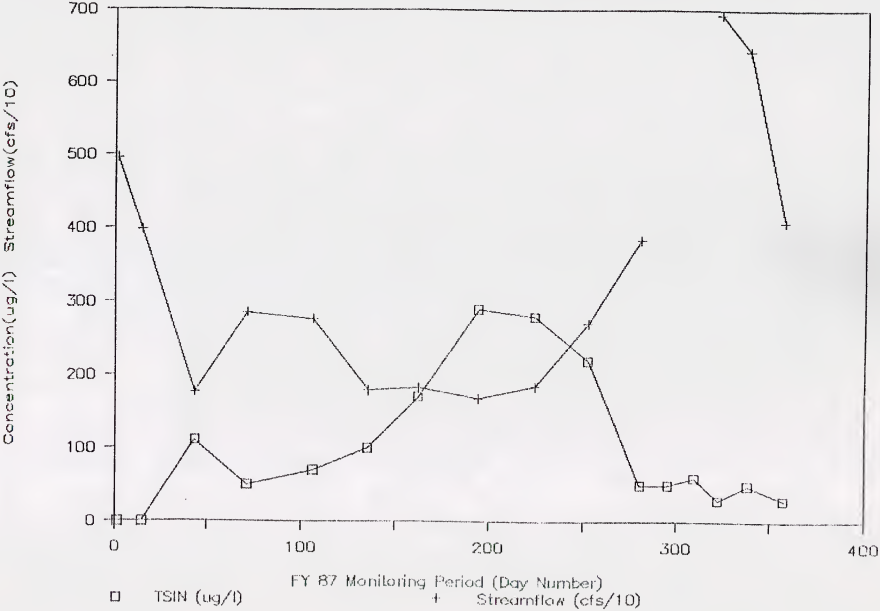
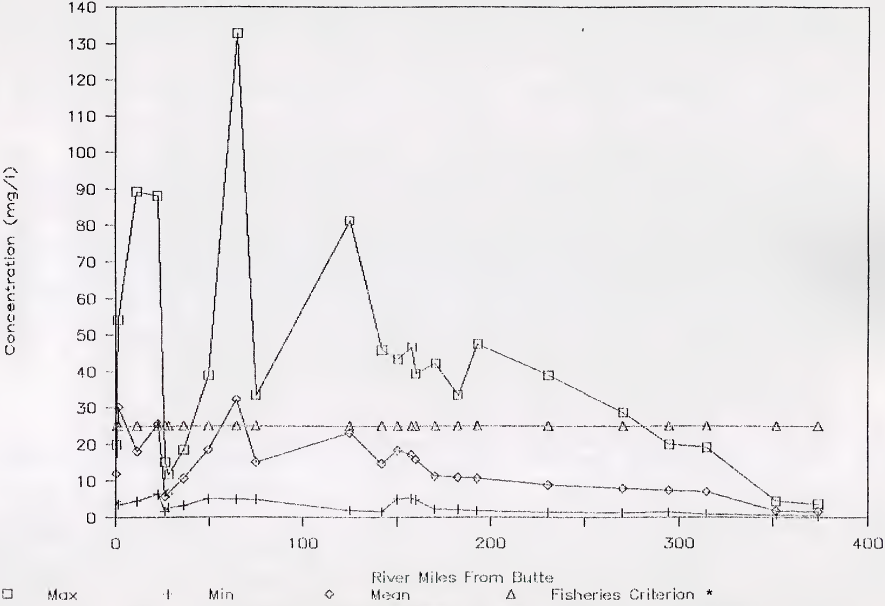


Figure 57. Maximum, minimum and annual mean total suspended sediment concentrations by stream mile in Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for the period July, 1986 through June, 1987.



* Concentration below which a high level of protection should be afforded to freshwater aquatic communities, including fisheries. EPA-R3-73-003, March, 1973.

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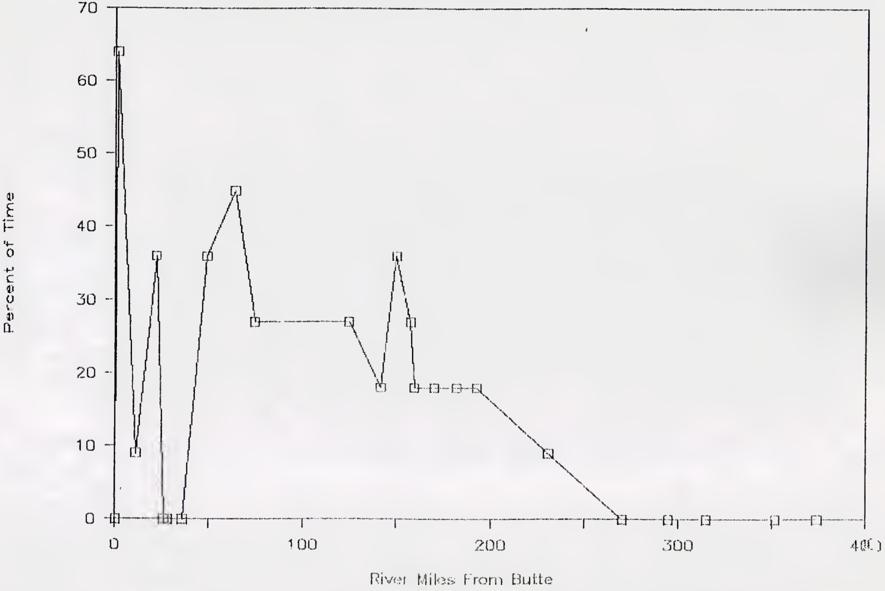

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* Concentration below which a high level of protection should be afforded to freshwater aquatic communities, including fisheries. EPA-R3-73-003, March, 1973.

Figure 59. Total suspended sediment severity scores by stream mile for Silver Bow Creek and the Clark Fork River from Butte, MT to below Cabinet Gorge Dam, ID for FY 1987.

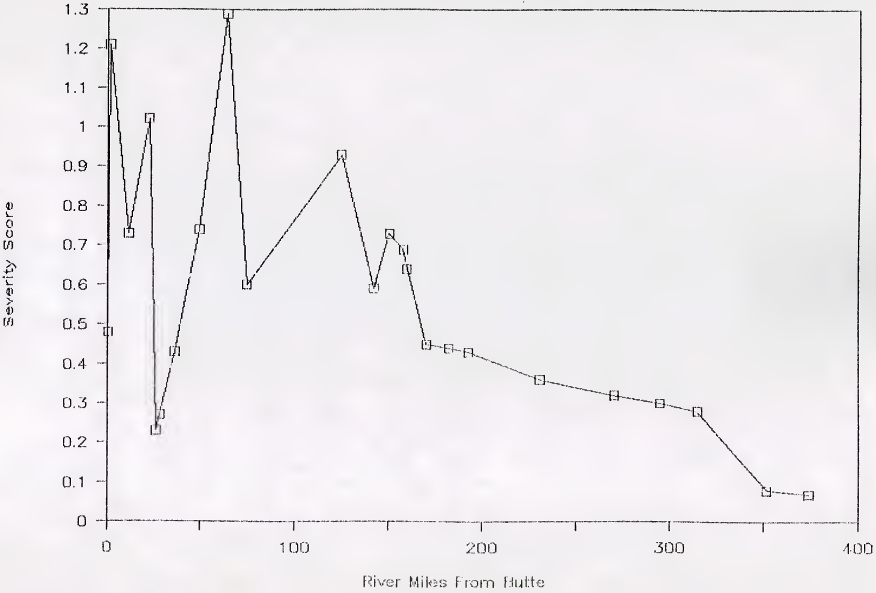


Figure 60. Maximum, annual mean and minimum total suspended sediment concentrations in tributaries and municipal and industrial wastewater discharges to the Clark Fork River for the period July, 1986 through June, 1987.

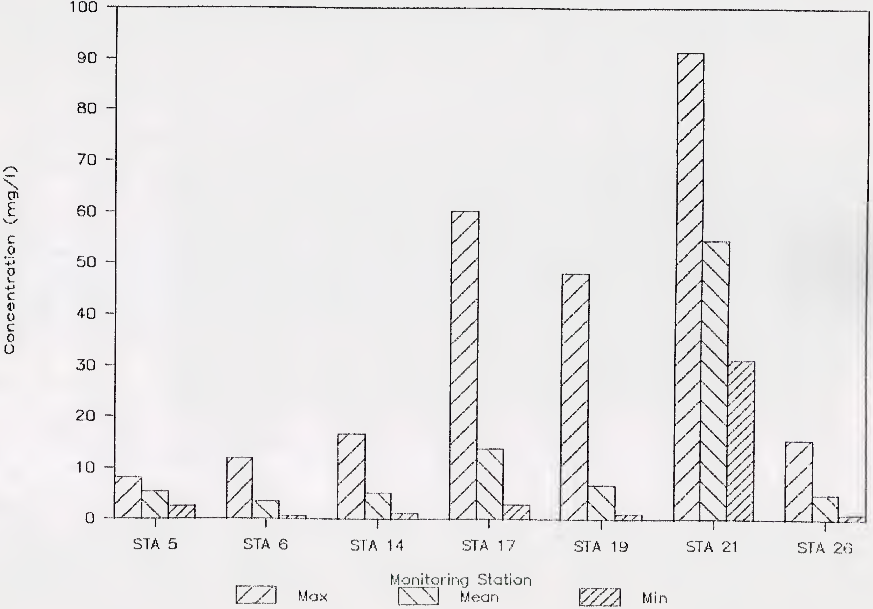
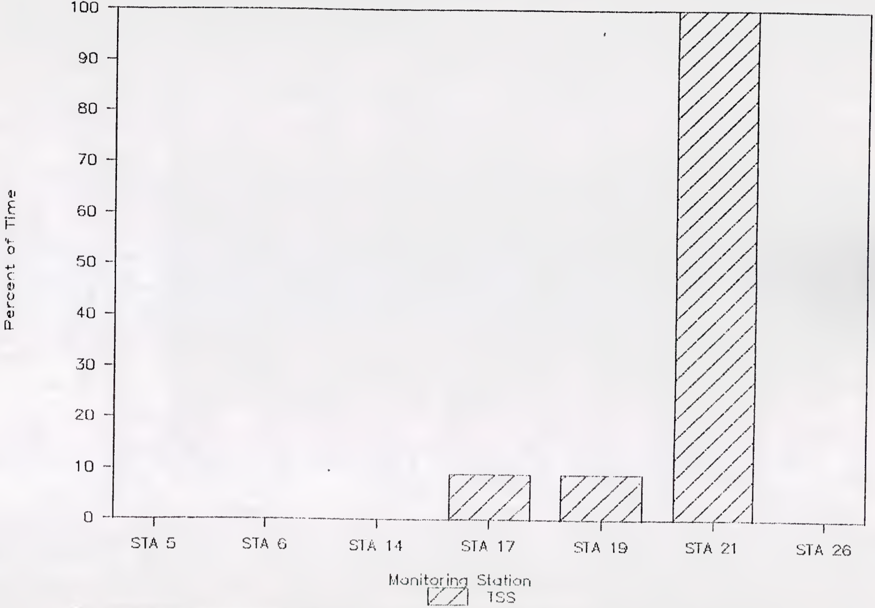


Figure 61. Frequency of total suspended sediment measurements in tributaries and municipal and industrial wastewater discharges to the Clark Fork River exceeding the criterion for the protection of freshwater aquatic communities* for the period July, 1986 through June, 1987.



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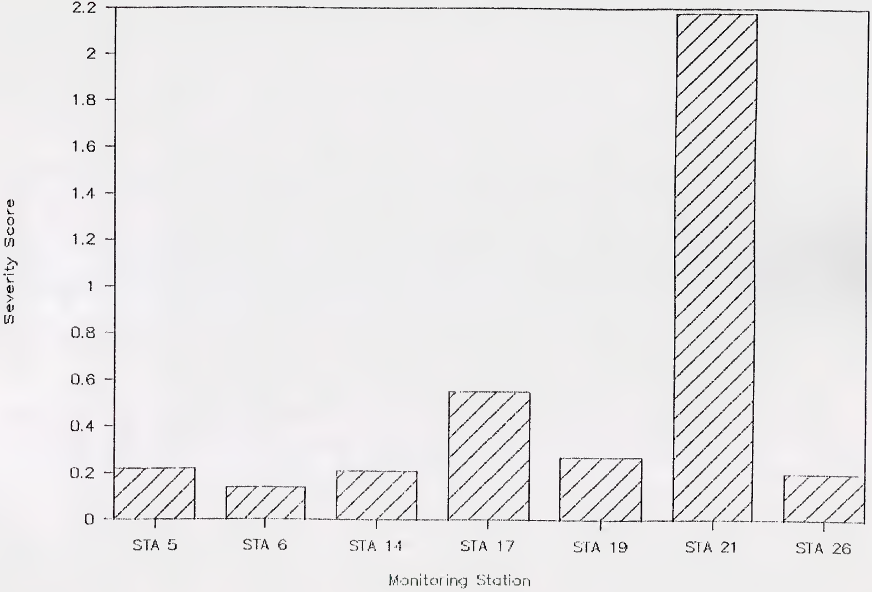
* Concentration below which a high level of protection should be afforded to freshwater aquatic communities, including fisheries. EPA-R3-73-003, March, 1973.

Figure 62. Total suspended sediment severity scores for tributaries and municipal and industrial wastewater discharges to the Clark Fork River for FY 1987.



3.2 Macroinvertebrate Community Structure

by Daniel L. McGuire

CLARK FORK RIVER MACROINVERTEBRATE STUDY, 1986

Prepared for the
Montana Governor's Office
and
the Montana Water Quality Bureau
Helena, Montana

Prepared by
Daniel L. McGuire
Espanola, New Mexico
June, 1987

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1.0 INTRODUCTION

Concern that industrial and municipal effluents, widespread metal contamination and non-point source pollution have degraded water quality in the Clark Fork River drainage has resulted in numerous water quality and biological monitoring programs. Recently, macrobenthos investigations have been conducted on various reaches of the Clark Fork River by the Montana Department of Health and Environmental Sciences (MDHES Biological Monitoring Reports 1979a and b; unpublished data 1980 and 1983; Hornig and Hornig 1985), U. S. Environmental Protection Agency (Janik and Melancon 1982), Anaconda Company (Canton and Chadwick 1985; Chadwick, Canton and Dent 1986), Montana Power Company (MPC 1982; McGuire 1984) and the Institute of Paper Chemistry (IPC annual reports beginning in 1956; Rades 1985). This is the first study to encompass the entire river, with 27 sampling locations between Butte and the Idaho border (Figure 1). As part of a comprehensive surveillance program, the purposes of this study are to monitor the integrity of macroinvertebrate assemblages in the river, to detect changes in water quality and to provide data for water-quality management decisions.

2.0 METHODS

2.1 Field work

Benthic macroinvertebrates were collected by Montana Governor's Office and Water Quality Bureau staff between August 11th and 21st, 1986. A modified Hess sampler was used to obtain four replicate samples at each of 23 stations between the headwaters of Silver Bow Creek and the Clark Fork River's confluence with the Flathead River (Figure 1). Further downstream, large substrates precluded the effective use of a Hess sampler; so modified traveling kick samples (per Hornig and Hornig 1985) were obtained at stations 26, 27, 28 and 30. At each station, photographs and field notes were taken to describe the physical habitat, floral composition and other pertinent conditions.

2.2 Laboratory analysis

Upon delivery to the laboratory, rose bengal dye was added to samples containing appreciable amounts of organic material (primarily Cladophora), and all samples were represerved in 80% isopropyl alcohol. This was done to facilitate recovery of small, soft-bodied organisms and to stabilize weights for biomass determination.

Macroinvertebrates were removed from debris in each sample and sorted to order. Nine samples (noted on the data sheets in Appendix C) were subsampled using a modification of the technique suggested by the U. S. Environmental Protection Agency (Weber 1973). To subsample, the sample was suspended in a U. S. Standard No. 30 sieve and thoroughly mixed. A divider was inserted into the sieve, which partitioned the sample into equal portions (quarters or eighths). Randomly-selected portions were recombined to form the subsample (half or quarter of the original sample).

The biomass of predominant macroinvertebrate orders was estimated as wet weight and determined to the nearest hundredth of a gram. Macroinvertebrates were identified to the lowest taxonomic level practical using the taxonomic references listed in Appendix B.

2.3 Data evaluation

Many approaches and techniques have been used to interpret macroinvertebrate responses to environmental perturbations. Since any single indice may be inappropriate under certain conditions, a thorough evaluation of data using a variety of techniques usually provides the most useful information from a data set (Lenat et al. 1982; Chadwick and Canton 1984). In this report, four levels of resolution (community, ordinal, functional groups and dominant taxa) were employed to evaluate numerous attributes of the aquatic macroinvertebrate community.

Similarities in the faunal composition among stations 1 through 25 were graphically evaluated using a single-linkage cluster analysis (Hellawell 1978) based on the percentage similarity coefficient (Whittaker 1975). By grouping stations with similar faunas, this analysis provided a biological basis for delineating river reaches and permitted a more meaningful evaluation of differences between stations. It is also a useful tool for confirming or refuting hypotheses and apriori classification schemes (e.g. impacts associated with heavy metals are more severe in Silver Bow Creek than in the upper Clark Fork River). Stations where modified kick samples were collected were excluded from this analysis.

After categorizing stations according to their relative compositional similarity, stations were compared using various measures of community structure. Community level analyses consisted of "single number" summaries, which included mean density (individuals/square meter), mean biomass (grams wet wt/square meter), taxa richness (total number of taxa per station and average number/sample), and Shannon Diversity (Weber 1973). Statistical comparisons of these

parameters were made with a single factor analysis of variance by ranks (Kruskal-Wallis test) and an appropriate multiple range test of significance between pairs of stations (Zar 1974). Non-parametric tests were employed because macroinvertebrate samples usually have heteroscedastic variances and, in many cases, non-normal distributions; conditions which violate underlying assumptions of parametric statistics.

Three other community level indices were calculated after analyses for this report were completed. Values for Equitability (Weber 1973), the Biotic Condition Index (Platts, Megahan and Minshall 1983) and a Biotic Index (Hilsenhoff 1977) were included among the summary statistics in Appendix C but were not evaluated in this report. In calculating the Biotic Index, pollution tolerance values assigned each taxon were obtained from Hilsenhoff (1982), Fraley (1979) or Oswald (1979).

Data were examined at three additional organizational levels (ordinal, functional group and genus/species) for trends between stations and clusters of stations. Abundance and percentage of total abundance (relative abundance) were calculated for orders and functional groups. In addition, taxa richness, biomass and relative biomass were determined at the ordinal level. Taxa dominating the summer fauna and shifts in the dominance hierarchy among selected taxa were noted. The lack of seasonal data precluded more detailed analyses of these parameters.

3.0 RESULTS

A total of 144 taxa were identified in samples collected during 1986 (Appendix A). Insects were represented by 125 taxa and noninsects by 19 taxa. Dipterans were the most diverse order, with 53 taxa, including 42 taxa of Chironomidae. Trichoptera, Ephemeroptera, Coleoptera and Plecoptera contributed 25, 19, 15 and 9 taxa, respectively. Single species of Lepidoptera, Megaloptera, Odonata and Hemiptera were collected. Although noninsects were poorly represented at most stations, the macroinvertebrate fauna included seven families of annelids, six genera of molluscs and single species of amphipod and sponge. Mites, flatworms, and cladocerans were each assigned to a single taxon.

The raw data and summary statistics are presented in Appendices C (numerical data) and D (biomass data) while percentage community similarity coeffients comprise Appendix E.

3.1 Cluster analysis

Cluster analysis, which groups stations by similarities in faunal composition, proved informative in several respects. Clark Fork River stations formed two distinct clusters which, with two exceptions, divided the river into upper and lower reaches (Figure 2). Demarcation of the two groups occured between station 12 (Bonita) and station 13 (Turah) which bracket the confluence of Rock Creek. Stations 20 (Harper's Bridge) and 22 (Huson), which are above and below the Stone Container Corporation's paper mill, were the exceptions to this longitudinal zonation. These two stations clustered with stations 7 through 12 on the upper Clark Fork River and station 5 (Mill-Willow Creek bypass), a tributary in the headwaters. The downstream cluster was comprised of seven stations on the mainstem of the Clark Fork River (stations 13, 15, 16, 18, 23, 24, and 25) and a station on the Bitterroot River (station 19).

All 15 stations on the Clark Fork River where Hess samples were taken had linked by the 0.54 percentage community similarity coefficient level (Figure 2 and Appendix Table 2), indicating a relatively similar summer fauna throughout the river. In contrast, each of the stations located on Silver Bow Creek (Stations 1-4) and station 14, on the Blackfoot River, had relatively unique faunas and did not form linkages above the 0.35 similarity level. The relatively high similarity values among Clark Fork River stations were expected; however, the failure of the Silver Bow Creek stations to cluster among themselves and the low similarity coefficients associated with the Blackfoot River require further consideration.

Data for the Blackfoot River (Appendix C, station 14) did not substantiate the widely held belief that it is a relatively unpolluted stream with good water quality and an excellent trout fishery (Watson 1985). The current data also contradicted previous macroinvertebrate studies in the Blackfoot River (Hornig and Hornig 1985; Montana Power Company 1982). For instance, at Wishard Bridge, approximately 2 km (1 mile) downstream of the present sampling location, Montana Power reported an average of 45 taxa with estimated densities exceeding 4,000 organisms per square meter in triplicate modified Hess samples collected on each of five occasions during 1980 and 1981. Since significant changes in water and habitat quality were not in evidence during 1986, the present samples were probably not representative of overall conditions in the Blackfoot River. The data may have indicated a localized perturbation (e.g. silt deposition) or may have been anomalous due to poor sampling conditions (e.g. fluctuating river stage). In either case, the data could not be used for comparison with Clark Fork River stations and was excluded from further analysis.

3.2 Community structure

Highly significant differences (ANOVA by rank, P = 0.01, 21 df) existed between stations for each community structure parameter examined (Table 1).

Taxa richness (Figure 3)

Taxa richness, a direct measure of community structure, is sensitive to toxic substances (Wielderholm 1984) and habitat degradation (Lenat 1984). LaPoint et al. (1984) reported that species richness accurately reflected changes in water quality of 15 streams (including Silver Bow Creek) contaminated with metals. Chadwick et al. (1986) found no invertebrates in annual samples from Silver Bow Creek from 1972 to 1974 and an impoverished, but increasing, number of taxa over the next 8 years. Taxa richness was an excellent indicator of metals toxicity in the present study.

During August 1986, the total number of taxa per station (Figure 3) was lowest (15) in Silver Bow Creek and highest (52) at station 15 (CFR below Milltown Dam). Taxa richness increased abruptly between station 3 (Silver Bow Creek above the Warm Springs ponds) and station 7 (CFR below Warm Springs Creek), was stable between stations 7 and 10, and began a gradual upward trend below the Clark Fork River's confluence with the Little Blackfoot River. Multiple range tests of significance (P = 0.05) detected a similar pattern for the mean number of taxa per sample (Table 1).

Shannon Diversity (Figure 4)

Mean diversity was lowest in Silver Bow Creek (station 1) and increased significantly below the Warm Springs settling ponds (Table 1). Unlike taxa richness however, diversity values were significantly lower at stations 9 (CFR @ Deer Lodge), 10 (CFR above the Little Blackfoot River), 12 (CFR @ Bonita) and 22 (CFR @ Huson) than at the remaining Clark Fork River stations. Since diversity indices are sensitive to a variety of environmental perturbations (Hellawell 1978; Ward and Stanford 1979), the significantly lower diversity values calculated for some Clark Fork River stations may have indicated a combination of environmental stresses. Nutrient and organic enrichment were probably the major factors affecting diversity at station 22 and were contributing factors at stations 9 and 10 where macroinvertebrate abundance was enhanced. Heavy-metal toxicity may have influenced diversity values in the upper Clark Fork River where low diversity values corresponded with elevated copper concentrations in sediments (Rice and Ray 1985) and water (Montana Water Quality Bureau unpublished data) in this reach.

Macroinvertebrate density (Figure 5)

Macroinvertebrate densities were suppressed by severe metal contamination in Silver Bow Creek at stations 2 and 3. Benthic organisms were more abundant at station 1 (Table 1) where acute toxicity was apparently lessened. Organic enrichment, dilution and (probably) transformation of metals into less toxic forms by the Butte sewage treatment plant's effluent allowed a few metal tolerant species to become locally abundant. Macroinvertebrate densities increased two orders of magnitude between stations 3 (above the Warm Springs Ponds) and 4 (below the Warm Springs Ponds). This increase was attributed to a significant reduction in heavy-metal toxicity which allowed a few macroinvertebrate and zooplankton populations to take advantage of the abundant food supply, elevated water temperatures, and constant flows at the outflow of the ponds. Significantly higher densities at stations 10 (Table 1) were interpreted as heavy-metal tolerant species responding to organic enrichment. Macroinvertebrate densities were relatively high throughout the Clark Fork River and were comparable to densities reported from nutrient-rich reaches of the Missouri River (McGuire 1983a and b).

Macroinvertebrate biomass (Figure 6)

Biomass trends were similar to those for abundance and implicated sewage treatment plants upstream of stations 1 and 10 and the paper mill above station 22 as point sources of organic enrichment. However, widespread enrichment was indicated by the high, relatively uniform biomass at main-stem stations. The largest biomass was recorded at station 13 (below the confluence of Rock Creek) where a large number of large Pteronarcys californica nymphs were collected.

3.3 Biocenoses

Orders

Ordinal data is well suited to detect metal pollution. At the ordinal level, species richness and relative abundance exhibit predictable, graduated responses to heavy-metal pollution (Hynes 1960; Wielderholm 1984). Numerous investigators have reported differential tolerances to heavy-metals among invertebrate groups with tolerance increasing from mayflies thru caddisflies to midges (e.g Armitage 1980; Winner et al. 1980).

In this study, since ordinal and functional group analyses were compromised by the lack of seasonal data, a detailed examination was not undertaken. Winner et al. (1980) emphasized the necessity of seasonal sampling to adequately characterize community structure. However, the severity of heavy-metal toxicity in Silver Bow Creek and a progressive improvement downstream to approximately station 13 was clearly indicated by the number of stonefly, mayfly and caddisfly taxa at each station (Table 2). Ordinal relative abundance (Table 3) and relative biomass (Table 4) confirmed the magnitude of heavy-metal toxicity in Silver Bow Creek, but provided no further insights with regard to water quality.

Functional groups

Among functional groups, collectors, primarily filter feeders such as hydropsychids and blackflies, dominated the August fauna. At stations below the Warm Springs Ponds (ACM settling ponds), hydropsychids and blackflies comprised, on the average, 64% of the fauna. The abundance of filter-feeding insects is influenced by the quality and quantity of fine particulate organic matter (Wallace and Merrit 1980) and was indicative of high seston levels throughout the Clark Fork River.

Dominant taxa

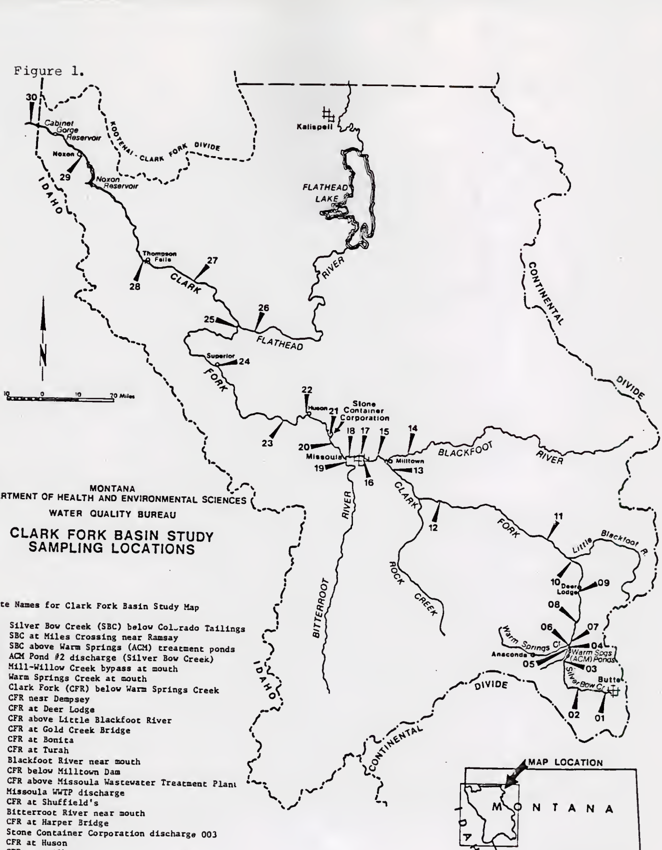
In addition to hydropsychids and blackflies, several other taxa were abundant in the summer fauna. Chironomidae were major components of the benthic fauna in all river reaches. Orthocladinae which were abundant throughout the river, predominated in Silver Bow Creek and the upper Clark Fork River while several species of the subfamily Chironominae were abundant from Turah (station 13) downstream. _Baetis_ (primarily _B. tricaudatus_ and _B. insignificans_) were the dominant mayflies at all stations upstream of the Clark Fork River's confluence with the Flathead River. Below the Flathead River, heptageniids (mostly _Stenonema_ sp.) and _Paraleptophlebia_ _bicornuta_ were the most abundant mayflies. Other mayfly species are known to be more abundant seasonally (Hornig and Hornig 1985).

Many taxa exhibited interesting distribution and abundance patterns which may entail useful information about water quality. For example, _Arctopsyche_ _grandis_ was not collected at stations (1-4 and 7-9 and only two specimens at station 10) where copper concentrations frequently exceeded E.P.A. criteria (G. Ingman, WQB, personal communication), but was common at other stations. At stations where moderate environmental stresses were detected (stations 7

through 12, 20 and 22), Hydropsyche (Hydropsyche) spp. (which included some H. occidentalis and many small larvae identifiable only to subgenus) was the most numerous taxon while other hydropsychids were dominant at the remaining stations (Cheumatopsyche sp. and H. morosa at station 4; Cheumatopsyche spp. at stations 23 through 28;and H. cockerelli at stations 15, 16 and 18). However, more frequent sampling would be required to ascertain if these observations reflect life history characteristics or responses to environmental conditions.

Although only superficially examined in this study, the macroinvertebrate fauna in the Clark Fork River below the confluence of the Flathead River differed substantially from upstream reaches. In addition to changes in the mayfly and dipteran biocenoses, seven genera of molluscs (six gastropods and a fingernail clam) were present in the lower reaches of the river that were rare or absent further upstream. Since these organisms are intolerant to copper, their distribution in the Clark Fork River may be limited by copper contamination. Gastropods may thus be useful as indicator organisms and test specimens for insitu bioassays.

Figure 1.



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WATER QUALITY BUREAU

CLARK FORK BASIN STUDY SAMPLING LOCATIONS

Site Names for Clark Fork Basin Study Map

01	Silver Bow Creek (SBC) below Colorado Tailings
02	SBC at Miles Crossing near Ramsay
03	SBC above Warm Springs (ACM) treatment ponds
04	ACM Pond #2 discharge (Silver Bow Creek)
05	Mill-Willow Creek bypass at mouth
06	Warm Springs Creek at mouth
07	Clark Fork (CFR) below Warm Springs Creek
08	CFR near Dempsey
09	CFR at Deer Lodge
10	CFR above Little Blackfoot River
11	CFR at Gold Creek Bridge
12	CFR at Bonita
13	CFR at Turah
14	Blackfoot River near mouth
15	CFR below Milltown Dam
16	CFR above Missoula Wastewater Treatment Plant
17	Missoula WWTP discharge
18	CFR at Shuffield's
19	Bitterroot River near mouth
20	CFR at Harper Bridge
21	Stone Container Corporation discharge 003
22	CFR at Huson
23	CFR near Alberton
24	CFR at Superior
25	CFR above Flathead River
26	Flathead River near mouth
27	CFR above Thompson Falls Reservoir
28	CFR below Thompson Falls Dam
29	CFR below Noxon Rapids Dam
30	CFR below Cabinet Gorge Dam

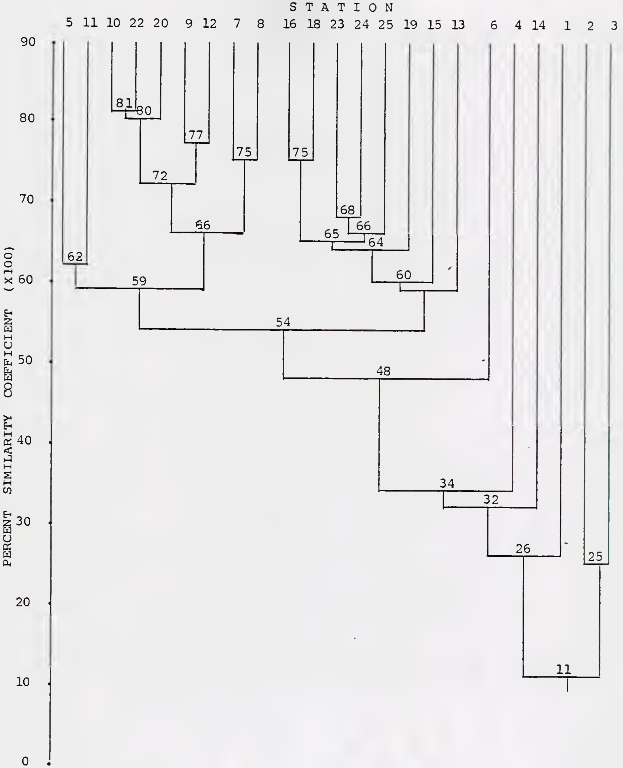

Figure 2. Cluster analysis using the percentage similarity coefficient (X100) for stations in the Clark Fork River drainage during August, 1986.

Table 1. Statistical analyses (Kruskal-Wallis test and multiple range test based on ranks) of taxa richness, Shannon Diversity, community density and community biomass at 22 stations in the Clark Fork River drainage during August, 1986 (Four replicate Hess samples at each station; ANOVA [P=0.01,21df] = 38.93).

	taxa richness	Diversity	density	biomass
ANOVA H =	70.79**	72.46**	68.69**	65.82**
MULTIPLE RANGE TEST				
Station	mean no. of taxa	mean Diversity	organisms/ sq. meter	grams/ sq. meter
1	8 a	1.35	6280 b	12.9 c
2	8 a	1.68 a	478 a	0.6 a
3	8 a	2.03 a	823 a	1.4 a
4	18 b	2.40	25580 c	48.1 d,e
5	25 c	3.21 b	3573	7.7 b
6	18 b	3.33 b	1220	6.8 b
7	26 c	2.88 b	8470 b	23.5 c,d
8	22 c	2.73	5893 b	14.1 c
9	25 c	1.74	14095 b	30.2 c,d,e
10	26 c	2.13 a	31308 c	51.3 e
11	29 c	3.23 b	8385 b	18.8 c
12	28 c	2.25 a	9485 b	26.3 c,d,e
13	34 d	3.69	15385 b	65.1 e
15	36 d	3.60 b	14300 b	36.4 c,d,e
16	28 c	2.93 b	6925 b	33.2 c,d,e
18	30 c	2.92 b	5838 b	32.7 c,d,e
19	34 d	3.60 b	8895 b	28.7 c,d,e
20	30 c	2.89 b	8098 b	29.2 c,d,e
22	29 c	2.52	13960 b	38.4 d,e
23	36 d	3.08 b	9895 b	39.7 d,e
24	33 d	3.46 b	5365 b	17.0 c
25	26 c	3.40 b	2490	8.3 b

means followed by common letters were not significantly different at P = 0.05 level.

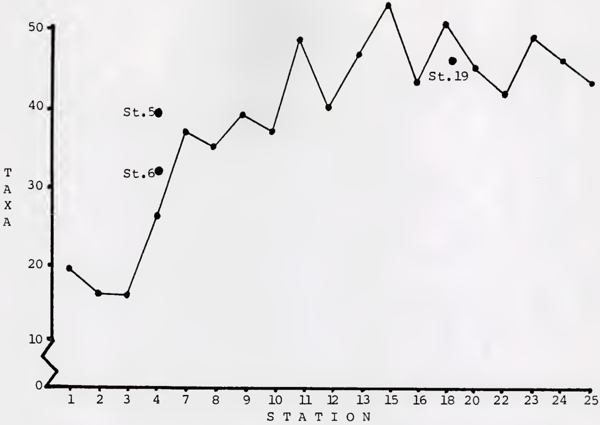

Figure 3. Macroinvertebrate taxa richness at Clark Fork River stations during August, 1986 (four Hess samples pooled at each station).

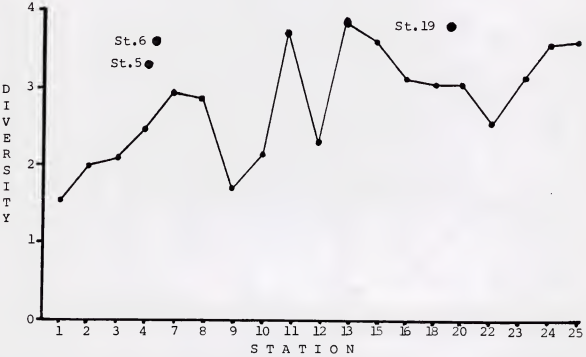

Figure 4. Shannon diversity at Clark Fork River stations during August, 1986 (four Hess samples pooled at each station).

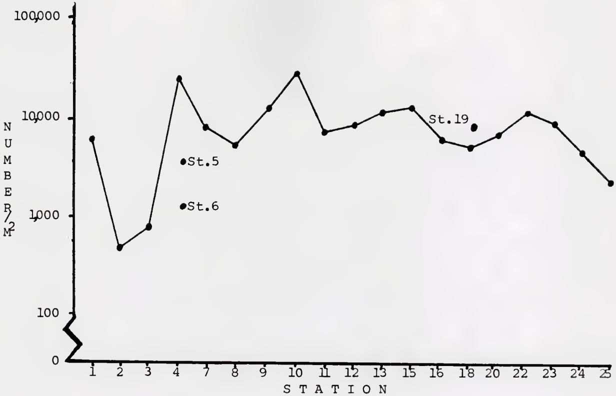

Figure 5. Mean macroinvertebrate density (organisms per square meter) at Clark Fork River stations during August, 1986.

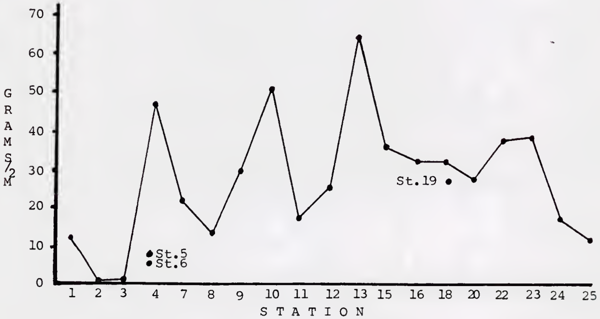

Figure 6. Mean macroinvertebrate biomass (grams wet weight per square meter) at Clark Fork River stations during August, 1986.

Table 2. The number of taxa per order at 26 stations in the Clark Fork drainage during August, 1986 (four Hess samples pooled at each station except 26, 27, 28 and 30, where kick samples were collected).

STATION	ORDER						
	Diptera	Trich.	Ephem.	Pleco.	Coleo.	Other	Total
1	12	1	1	0	4	0	18
2	8	1	1	0	4	1	15
3	5	4	0	0	3	3	15
4	9	6	0	0	2	8	25
5	16	9	5	3	3	2	38
6	11	7	3	3	6	0	30
7	16	7	2	3	4	4	36
8	14	6	3	3	5	3	34
9	18	7	3	4	4	2	38
10	16	8	5	3	3	1	36
11	23	9	7	5	3	1	48
12	19	7	8	2	3	0	39
13	18	9	10	6	3	0	46
15	20	10	9	7	4	2	52
16	13	11	6	5	3	4	42
18	19	8	10	6	3	3	49
19	18	8	8	4	4	3	45
20	19	7	9	5	3	1	44
22	15	9	7	5	3	2	41
23	17	11	9	6	3	2	48
24	17	11	8	4	3	2	45
25	15	11	11	1	2	2	42
26	6	3	5	0	2	4	20
27	15	7	9	2	4	11	48
28	7	3	4	0	0	1	15
30	11	6	4	0	0	5	26

Table 3. The percentage relative abundance (X100) of macroinvertebrate orders at 26 stations in the Clark Fork River drainage during August, 1986 (four Hess samples pooled at each station except 26, 27, 28 and 30, where kick samples were collected).

STATION	ORDER					
	Diptera	Trich.	Ephem.	Pleco.	Coleo.	Other
1	100	+	+	0	+	0
2	82	5	1	0	8	4
3	27	59	0	0	12	2
4	23	47	0	0	3	27
5	34	45	16	2	2	1
6	9	22	20	35	14	0
7	9	60	7	10	12	2
8	9	61	10	8	12	+
9	9	74	11	2	4	+
10	28	60	9	2	1	+
11	33	33	26	6	1	+
12	13	64	18	3	2	0
13	39	43	10	4	4	0
15	38	46	7	6	3	+
16	13	76	7	1	2	1
18	10	76	9	4	+	1
19	19	56	9	5	10	1
20	19	58	20	2	1	+
22	18	65	13	2	2	+
23	6	75	13	2	1	3
24	16	68	11	1	1	3
25	21	65	6	3	1	4
26	9	21	52	0	7	11
27	28	38	14	+	5	15
28	64	14	12	0	0	10
30	30	10	57	0	0	3

+ indicates less than 1%

Table 4. The percentage relative biomass (X100) of macroinvertebrate orders at 22 stations in the Clark Fork River drainage during August, 1986 (four Hess samples pooled at each station).

STATION	ORDER					
	Diptera	Trich.	Ephem.	Pleco.	Coleo.	Other
1	100	+	+	0	+	0
2	72	12	+	0	16	0
3	16	65	0	0	19	+
4	23	42	0	0	2	34
5	20	60	14	6	+	+
6	6	8	4	80	3	0
7	6	55	4	31	4	+
8	9	53	4	27	6	1
9	8	75	5	10	1	1
10	18	61	8	14	+	0
11	17	50	7	26	1	0
12	31	48	6	15	1	0
13	10	36	3	50	1	0
15	9	55	2	32	1	+
16	2	68	1	27	+	0
18	1	75	2	21	+	+
19	5	71	4	11	7	2
20	8	77	6	9	+	+
22	10	65	5	19	1	+
23	1	85	5	7	+	2
24	4	75	4	12	+	5
25	4	78	4	8	+	6

+ indicates less than 1%.

4.0 CONCLUSIONS

Four main conclusions may be drawn from the 1986 macroinvertebrate data:

1. Macroinvertebrates were sensitive to toxic conditions in the Clark Fork River drainage. A relative measure of the biological significance of heavy-metal contamination was provided by an integrated evaluation of species richness, abundance, community composition and diversity.

2. Silver Bow Creek remains severely polluted with heavy-metals.

3. Moderate heavy-metal contamination was indicated in the Clark Fork River above the confluence of Rock Creek (stations 7-12).

4. The relatively high densities and large biomass of macroinvertebrates indicated nutrient and organic enrichment throughout the Clark Fork River and, except where suppressed by heavy-metals, in Silver Bow Creek.

Site specific conclusions:

5. At station 1 (Silver Bow Creek below the Colorado tailings), a relative increase in the abundance of blackflies and midges suggested organic enrichment and a localized reduction in toxic conditions by dilution and/or complexing of metals by the Butte sewage treatment plant effluent.

6. At stations 2 and 3 in Silver Bow Creek, toxic conditions resulted in an impoverished macroinvertebrate fauna which consisted of a few tolerant species present in low numbers.

7. A substantial reduction in heavy-metal toxicity occurred in and below the Warm Springs settling ponds. A significant increase in the number of taxa was attributed to the effects of liming, settling of metal-bearing sediments and dilution by Mill, Willow and Warm Springs creeks.

8. At station 4, immediately below the settling ponds, order of magnitude increases in macroinvertebrate abundance and biomass resulted from the cumulative effects of many favorable environmental factors. In the less toxic environment, a few macroinvertebrate and zooplankton populations flourished, responding to an abundant food supply, elevated water temperatures and constant flows. Although their influence was diminished with distance, these factors had a detectable impact on macroinvertebrates at stations 7 and 8 in the upper Clark Fork River.

9. Multiple environmental stresses were apparent from station 7 to 12 on the upper Clark Fork River. Varying degrees of heavy-metal toxicity and nutrient enrichment were indicated at each station. Organic enrichment was particularly evident at station 10 (CFR above the Little Blackfoot River).

10. At station 11, (CFR at Gold Creek) a localized reduction in toxicity may have been indicated, however, it did not extend downstream to station 12 (CFR at Bonita).

11. Below the confluence of Rock Creek (station 13, CFR at Turah) all parameters indicated a substantial reduction in the biological significance of heavy-metal contamination.

12. Significant environmental stresses were not apparent at station 15 below Milltown Dam. Macroinvertebrates were not, however, as abundant as expected below a shallow impoundment on a nutrient-rich river, suggesting that productivity in the reservoir may be limited by metal-laden sediments. ? low retention

13. No differences were detected between stations above (station 16) and below (station 18) the Missoula sewage treatment outfall.

14. Relatively high macroinvertebrate density and biomass at stations 22 (CFR at Huson) and 23 (CFR near Alberton) were attributed to the cumulative effects of enrichment from upstream sources, including the Missoula sewage treatment plant and the Frenchtown paper mill.

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CLARK FORK RIVER MACROINVERTEBRATE STUDY, 1986

APPENDICES

APPENDIX A

A checklist of macroinvertebrates identified in samples collected from the Clark Fork River drainage, Montana, during August 1986.

TAXON

- Arthropoda
  - Arahnida
    - HYDROCARINA
  - Crustacea
    - CLADOCERA
    - AMPHIPODA
      - Talitridae
        - *Hyalella azteca*
  - Insecta
    - EPHEMEROPTERA
      - Siphlonuridae
        - *Ameletus* sp.
      - Baetidae
        - *Baetis bicaudatus*
        - *Baetis insignificans*
        - *Baetis tricaudatus*
        - *Psuedocloeon* sp.
      - Heptageniidae
        - *Epeorus albertae*
        - *Epeorus longimanus*
        - *Heptagenia soltaria*
        - *Nixe* sp.
        - *Rhithrogena* sp. (some *R. hageni*)
        - *Stenonema* sp.
      - Ephemerellidae
        - *Attenella margarita*
        - *Drunella grandis*
        - *Drunella doddsi*
        - *Ephemerella inermis/infrequens*
        - *Serratella tibialis*
        - *Timpango hecuba*
      - Tricorythidae
        - *Tricorythodes minutus*
      - Leptophlebiidae
        - *Paraleptophlebia bicornuta*
    - ODONATA
      - Gomphidae
        - *Ophiogomphus* sp.

- PLECOPTERA
  - Pteronarcidae
    - *Pteronarcella badia*
    - *Pteronarcys californica*
  - Perlidae
    - *Claassinia sabulosa*
    - *Doroneuria theodora*
    - *Hesperoperla pacifica*
  - Perlodidae
    - *Isogenoides sp.*
    - *Skwala* sp.
  - Chloroperlidae
    - Chloroperlinae (unidentified)
    - *Sweltsa* sp.
- HEMIPTERA
  - Corrixidae (immature)
- MEGALOPTERA
  - Sialidae
    - *Sialis* sp.
- TRICHOPTERA
  - Philopotamidae
    - *Wormaldia* sp.
  - Psychomyiidae
    - *Psychomyia flavida*
  - Polycentropididae
    - *Polycentropus* sp.
  - Hydropsychidae
    - *Arctopyche grandis*
    - *Cheumatopsyche* spp.
    - *Hydropsyche*
      - (Ceratopsyche) sp.1
      - (Ceratopsyche) sp.2
      - (Ceratopsyche) sp.3
      - (Hydropsyche) spp.
  - Rhyacophilidae
    - *Rhyacophila acropedes*
    - *Rhyacophila* sp.1
  - Glossosomatidae
    - *Agapetus* sp.
    - *Glossosoma* sp.
  - Hydroptilidae
    - *Hydroptila* spp.
    - *Luecotrichia* sp.
    - *Ochrotrichia* sp.
    - *Zumatrichia notosa*
  - Brachycentridae
    - *Brachycentrus* sp.(small larvae at upstream sites)
    - *Brachycentrus occidentalis*

TRICHOPTERA (continued)
- Limnephilidae
  - Dicosmoecus sp.
- Helicopsychidae
  - Helicopsyche borealis
- Leptoceridae
  - Ceraclea sp. 1
  - Ceraclea sp. 2
  - Oecetis sp.
  - Mystacides sp.

LEPIDOPTERA
- Pyralidae
  - Petrophila sp. (=Paragyractis)

COLEOPTERA
- Haliplidae
  - Brychius sp.
  - Haliplus sp.
- Dytiscidae
  - Agabus sp.
  - Deronectes sp.
  - Oreodytes sp.1
  - Oreodytes sp.2
- Hydrophilidae
  - Hydrophilus sp.
- Elmidae
  - Cleptelmis ornata
  - Dubiraphia sp.
  - Heterlimnius sp.
  - Narpus concolor
  - Optioservus quadrimaculatus/seriatus
  - Optioservus divergins/pecosensis
  - Promoresia (?) sp.
  - Zaitzevia parva

DIPTERA
- Tipulidae
  - Antocha sp.
  - Hexatoma sp.
  - Tipula sp.
- Culicidae
  - Aedes sp.
- Ceratopogonidae
  - Ceratopogoninae (Palpomyia complex)
- Simuliidae
  - Simulium spp.

DIPTERA (continued)
- Chironomidae
  - Tanypodinae
    - *Apsectrotanypus* sp.
    - *Pentaneura* (?) sp.
    - *Thienemannimyia* sp.
    - Thienemannimyia group
  - Diamesinae
    - *Pagastia* sp.
    - *Potthastia* gaedii group
    - *Potthastia* longimana group
  - Prodiamesinae
    - *Monodiamesa* sp.
    - *Odontomesa* sp.
  - Orthocladiinae
    - *Cardiocladius* spp.
    - *Corynoneura* sp.
    - *Cricotopus*
      - (Cricotopus) bicinctus group
      - (C.) tremelus group (spp.)
      - (C.) trifascia gp
      - (C.) or *Orthocladius* (O.)
      - (Isocladius) sylvesrtris group
      - (Nostococladius)
    - *Eukiefferiella*
      - brehmi group
      - claripennis group (spp)
      - coerulescens group
      - gracei group
    - *Nanocladius* parvulus group
    - *Orthocladius* sp.
      - (Orthocladius) spp.
      - (Eudactocladius) sp.
      - (Euorthocladius) sp.
    - *Paraphaenocladius* sp.
    - *Parametriocnemus* sp.
    - *Synorthocladius* sp.
    - *Thienemanniella* sp.
    - *Tvetenia* spp.
  - Chironominae
    - Chironomini
      - *Cryptochironomus* sp.
      - *Dicrotendipes* sp.
      - *Glyptotendipes* species group A (Wiederholm 1983)
      - *Microtendipes* pedellus group
      - *Paracladopelma* sp.
      - *Parachironomus* frequens group
      - *Phaenopsectra* sp.
      - *Polypedilum* spp.
      - *Pseudochironomus* sp.
    - Tanytarsini
      - *Cladotanytarsus* vanderwulpi group
      - *Micropsectra* sp.
      - *Rheotanytarsus* sp.
      - *Tanytarsus* sp.

- Diptera (continued)
  - Tanyderidae
    - *Protanyderus* sp.
  - Athericidae
    - *Atherix* *pachypus*
  - Empididae
    - *Chelifera* sp.
    - unidentified Empididae
  - Muscidae
    - *Limnophora* sp.

- Annelida
  - Oligochaeta
    - Enchytraeidae
    - Lumbricidae
    - Lumbriculidae
    - Tubificidae
      - *Limnodrilus* *hoffmeisteri*
      - tubificid (unidentified)
    - Naididae
      - *Ophiodonais* *serpintina*
  - Hirudinea
    - Erobdellidae
    - Glossophoniidae

- Mollusca
  - Gastropoda
    - Ancyclidae
      - *Ferrissia* sp.
    - Lymnaeidae
      - *Lymnaea* sp.
    - Physidae
      - *Physa* sp.
    - Planorbiidae
      - *Gyraulus* sp.
      - *Helisoma* sp.
  - Pelecypoda
    - Sphaeriidae
      - *Sphaerium*
- Platyhelminthes
  - Turbellaria

- Porifera
  - Demospongiae
    - Spongillidae

- Phylum
  - Class
    - ORDER
      - Family
        - Subfamily
          - Tribe
            - Genus species (or species group)
              - (subgenus) species (or species group)

APPENDIX B

Taxonomic references used to identify macroinvertebrates collected during August, 1986 from the Clark Fork River

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APPENDIX C

CLARK FORK RIVER MACROINVERTEBRATE STUDY

NUMERICAL DATA AND SUMMARY STATISTICS

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 1 (Silver Bow Creek below Colorado tailings)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
DIPTERA						100	6280	
unassoc. chiron pupa	9	0	0	5	14	1	35	44
Aedes sp.	0	1	0	0	1	0	3	5
Apsectrotanypus sp.	0	0	1	0	1	0	3	5
Cardiocladius sp.	3	4	27	24	58	2	145	128
Chelifera sp.	0	0	2	0	2	0	5	10
Cricotopus								
(C.) tremelus group	313	77	70	464	924	37	2310	1921
(I.) sylvestris grp	49	9	8	143	209	8	523	634
Dicrotendipes sp.	0	0	0	1	1	0	3	5
Eukiefferiella claripennis group	3	1	0	13	17	1	43	60
Orthocladius (Orthocladius) sp.	0	0	0	1	1	0	3	5
Pagastia sp.	0	0	1	0	1	0	3	5
Simulium spp.	156	225	350	543	1274	51	3185	1698
Thienemannimyia sp.	2	0	0	1	3	0	8	10
EPHEMEROPTERA						0	3	
Drunella sp.	0	0	0	1	1	0	3	5
COLEOPTERA						0	10	
Brychius sp.	0	1	0	0	1	0	3	5
Deronectes sp.	0	1	0	0	1	0	3	5
Optioservus quadrimaculatus	0	0	1	0	1	0	3	5
Zaitzevia parva	0	0	1	0	1	0	3	5
TRICHOPTERA						0	3	
Hydropsyche (Ceratopsyche) sp.2	0	0	0	1	1	0	3	5
TOTAL NUMBER	535	319	461	1197	2512	100	6280	3898
TOTAL TAXA	6	8	9	10	19		8	2
S.W. DIVERSITY	1.40	1.18	1.17	1.64	1.57		1.35	0.22
EQUITABILITY	0.55	0.34	0.30	0.40	0.20		0.40	0.11
BIOTIC INDEX					3.41			
BIOTIC CONDITION INDEX					49			

STATION: 2 (Silver Bow Creek near Ramsey)
DATE: August 11, 1986
SAMPLE TYPE: modified Hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						82	390	
unassoc. chiron pupa	0	0	0	1	1	1	3	5
Antocha sp.	0	1	0	0	1	1	3	5
Apsectrotanypus sp.	0	0	0	2	2	1	5	10
Cardiocladius sp.	32	11	50	34	127	66	318	160
Chelifera sp.	0	0	3	0	3	2	8	15
Cricotopus (C.) tremelus group	2	3	3	0	8	4	20	14
Eukiefferiella gracei group	1	0	0	0	1	1	3	5
Limnophora sp.	0	2	0	0	2	1	5	10
Pagastia sp.	1	1	8	1	11	6	28	35
EPHEMEROPTERA						1	3	
Baetis tricaudatus	0	0	1	0	1	1	3	5
COLEOPTERA						8	38	
Agabus sp.	0	1	0	0	1	1	3	5
Deronectes sp.	2	6	2	0	10	5	25	25
Haliplus sp.	0	1	0	0	1	1	3	5
Optioservus quadrimaculatus	1	0	1	1	3	2	8	5
TRICHOPTERA						5	25	
Hydropsyche (Ceratopsyche) sp.2	4	2	4	0	10	5	25	19
HYDRACARINA	0	1	8	0	9	5	23	39
TOTAL NUMBER	43	29	80	39	191	100	478	223
TOTAL TAXA	7	10	9	4	16		8	3
S.W. DIVERSITY	1.43	2.71	1.95	0.64	2.00		1.68	0.87
EQUITABILITY	0.48	0.91	0.56	0.45	0.33		0.60	0.21
BIOTIC INDEX					3.00			
BIOTIC CONDITION INDEX					50			

STATION: 3 (Silver Bow Creek @ frontage road)
DATE: August 11, 1986
SAMPLE TYPE: modified Hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
DIPTERA						27	225	
Chiromonidae pupa	1	1	0	1	3	1	8	5
Atherix pachypus	0	0	1	0	1	0	3	5
Cardiocladius sp.	7	16	5	8	36	11	90	48
Pagastia sp.	3	13	26	5	47	14	118	104
Simulium sp.	0	2	0	0	2	1	5	10
Thienemannimyia sp.	1	0	0	0	1	0	3	5
COLEOPTERA						12	103	
Optioservus quadrimaculatus	0	4	2	0	6	2	15	19
Oreodytes sp.1	13	10	6	5	34	10	85	37
Zaitzevia parva	0	1	0	0	1	0	3	5
MEGALOPTERA						0	3	
Sialis sp.	0	1	0	0	1	0	3	5
TRICHOPTERA						59	488	
Brachycentrus sp.1	0	1	0	1	2	1	5	6
Cheumatopsyche sp.	0	1	0	1	2	1	5	6
Hydropsyche								
(Ceratopsyche) sp.1	0	5	3	2	10	3	25	21
(Ceratopsyche) sp.2	10	70	85	16	181	55	453	378
AMPHIPODA						0	3	
Hyallela azteca	1	0	0	0	1	0	3	5
HYDRACARINA	0	0	1	0	1	0	3	5
TOTAL NUMBER	36	125	129	39	329	100	823	517
TOTAL TAXA	6	11	8	7	16		8	2
S.W. DIVERSITY	2.11	2.15	1.58	2.27	2.11		2.03	0.31
EQUITABILITY	0.95	0.54	0.47	0.93	0.36		0.72	0.25
BIOTIC INDEX					2.95			
BIOT. COND. INDEX					51			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 4 (A.C.M. pond 2 discharge - SBC)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
DIPTERA						23	5935	
unassoc. chiron pupa	22	12	6	13	53	1	133	66
Antocha sp.	5	4	1	3	13	0	33	17
Atherix pachypus	3	6	5	3	17	0	43	15
Cardiocladius sp.	12	0	0	3	15	0	38	57
Cricotopus								
(C.)/Orthocladius	39	9	7	12	67	1	168	150
(C.) trifascia gp	79	2	1	11	93	1	233	374
(C.) tremelus gp	6	5	0	0	11	0	28	32
Glyptotendipes species group A	4	7	4	1	16	0	40	24
Simulium spp.	1299	345	228	216	2088	20	5220	5213
Tvetenia sp.	1	0	0	0	1	0	3	5
COLEOPTERA						3	690	
Optioservus								
divergins/pecosensis	16	8	9	7	40	0	100	41
quadrimaculatus	112	34	43	47	236	2	590	357
TRICHOPTERA						47	11918	
Cheumatopsyche sp.	1041	310	564	485	2400	23	6000	3126
Hydropsyche								
(Ceratopsyche) sp.2	1	0	1	0	2	0	5	6
(Ceratopsyche) sp.3	655	397	486	544	2082	20	5205	1081
(Hydropsyche) sp.1	118	74	62	25	279	3	698	383
Helicopsyche borealis	1	0	0	0	1	0	3	5
Oecetis sp.	2	0	1	0	3	0	8	10
AMPHIPODA						27	6858	
Hyalella azteca	852	437	643	811	2743	27	6858	1889
GASTROPODA						0	123	
Gyraulus sp.	4	0	5	1	10	0	25	24
Physa sp.	6	3	23	7	39	0	98	90
HIRUDINEA						0	50	
Erobdellidae	5	3	5	4	17	0	43	10
Glossophoniidae	0	0	3	0	3	0	8	15

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 4 (CONCLUDED)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
HYDRACARINA	1	0	0	0	1	0	3	5
OLIGOCHAETA								
Tubificidae	0	0	0	1	1	0	3	5
TURBELLARIA	0	0	1	0	1	0	3	5
TOTAL NUMBER	4284	1656	2098	2194	10232	100	25580	11743
TOTAL TAXA	22	15	19	17	26		18	3
S.W. DIVERSITY	2.49	2.48	2.39	2.24	2.49		2.40	0.12
EQUITABILITY	0.35	0.51	0.37	0.37	0.30		0.40	0.07
BIOTIC INDEX					3.29			
BIOT. COND. INDEX					49			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 5 (Mill-Willow Creeks bypass)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

	SAMPLE #				SUM	%RA	MEAN	STAND
TAXON	A	B	C	D			#/m2	DEV
DIPTERA						34	1228	
unassoc. chiron pupa	1	1	1	0	3	0	8	5
Antocha sp.	3	3	3	1	10	1	25	10
Atherix pachypus	0	3	2	3	8	1	20	14
Cardiocladius sp.	2	2	4	6	14	1	35	19
Cricotopus								
(C.) tremelus gp	0	9	0	8	17	1	43	49
(C.)/Orthocladius	8	2	0	1	11	1	28	36
(N.) nostocladius gp	3	0	5	11	19	1	48	46
Eukiefferiella								
brehmi gp	0	0	2	0	2	0	5	10
claripennis gp	0	0	1	2	3	0	8	10
Hexatoma sp.	1	0	1	0	2	0	5	6
Micropsectra sp.	0	1	0	0	1	0	3	5
Microtendipes sp.								
pedellus gp	5	1	15	22	43	3	108	95
Pagastia sp.	1	12	3	11	27	2	68	56
Phaenopsectra sp.	1	0	0	0	1	0	3	5
Rheotanytarsus sp.	0	0	0	1	1	0	3	5
Simulium sp.	5	74	77	166	322	23	805	660
Tvetenia sp.	1	2	2	2	7	0	18	5
EPHEMEROPTERA						16	588	
Baetis tricaudatus	27	77	59	67	230	16	575	216
Epeorus sp.	0	0	0	1	1	0	3	5
Heptageniidae sp. 1	1	0	0	0	1	0	3	5
Drunella grandis	0	0	0	2	2	0	5	10
Tricorythodes								
minutus	0	1	0	0	1	0	3	5
COLEOPTERA						2	63	
Optioservus								
quadrimaculatus	2	1	4	8	15	1	38	31
Oreodytes sp.1	1	0	0	1	2	0	5	6
Zaitzevia parva	1	2	3	2	8	1	20	8
PLECOPTERA						1	45	
Hesperoperla								
pacifica	0	0	0	1	1	0	3	5
Pteronarcella badia	2	0	1	7	10	1	25	31
Skwala sp.	7	0	3	8	18	1	45	37

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 5 (CONCLUDED)

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
TRICHOPTERA						45	1613	
Agapetus sp.	3	2	2	4	11	1	28	10
Arctopsyche grandis	1	1	3	4	9	1	23	15
Cheumatopsyche spp.	9	12	17	95	133	9	333	413
Hydropsyche								
(Ceratopsyche) sp.1	20	32	34	65	151	11	378	192
(Ceratopsyche) sp.2	6	5	4	4	19	1	48	10
(Ceratopsyche) sp.3	0	0	2	1	3	0	8	10
(Hydropsyche) spp.	49	51	66	150	316	22	790	479
Hydroptila sp.	0	1	0	1	2	0	5	6
Rhyacophila acropedes	0	1	0	0	1	0	3	5
AMPHIPODA						0	8	
Hyalella azteca	1	1	1	0	3	0	8	5
GASTROPODA								
Gyraulus sp.	0	0	0	1	1	0	3	5
TOTAL NUMBER	161	297	315	656	1429	100	3573	2107
TOTAL TAXA	24	23	24	30	39		25	3
S.W. DIVERSITY	3.44	3.02	3.20	3.19	3.34		3.21	0.17
EQUITABILITY	0.65	0.50	0.54	0.43	0.37		0.53	0.09
BIOTIC INDEX					2.95			
BIOT. COND. INDEX					55			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 6 (Warm Spr. Creek near mouth)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
DIPTERA						9	108	
unassoc. chiron pupa	0	1	0	1	2	0	5	6
Empididae pupa	0	1	0	0	1	0	3	5
Hexatoma sp.	3	1	0	3	7	1	18	15
Micropsectra sp.	0	0	0	1	1	0	3	5
Orthocladius (O.)sp.	0	0	0	1	1	0	3	5
Pagastia sp.	3	6	7	1	17	3	43	28
Paraphaenocladius sp	0	2	0	0	2	0	5	10
Phaenopsectra sp.	0	0	0	1	1	0	3	5
Protanyderus sp.	0	1	0	0	1	0	3	5
Rheotanytarsus sp.	0	1	0	0	1	0	3	5
Simulium sp.	0	2	1	0	3	1	8	10
Tvetenia sp.	0	2	0	4	6	1	15	19
EPHEMEROPTERA						20	248	
Baetis tricaudatus	32	32	20	12	96	20	240	98
Tricorythodes minutus	0	1	0	0	1	0	3	5
Drunella grandis	1	0	0	1	2	0	5	6
COLEOPTERA						14	170	
Zaitzevia parva	1	0	0	3	4	1	10	14
Heterlimnius sp.	0	1	0	0	1	0	3	5
Oreodytes sp. 1	0	1	1	0	2	0	5	6
Optioservus								
quadrimaculatus	17	15	3	12	47	10	118	62
divergins/pecosensis	2	0	2	3	7	1	18	13
Promoresia (?) sp.	0	3	0	4	7	1	18	21
PLECOPTERA						35	428	
Hesperoperla pacifica	8	2	2	11	23	5	58	45
Pteronarcella badia	41	18	1	9	69	14	173	173
Skwala sp.	43	7	10	19	79	16	198	163

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 6 (CONCLUDED)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
TRICHOPTERA						22	268	
Agapetus sp.	10	2	0	2	14	3	35	44
Arctopsyche grandis	0	7	0	2	9	2	23	33
Brachycentrus sp.1	0	1	0	0	1	0	3	5
Cheumatopsyche spp.	0	2	1	1	4	1	10	8
Hydropsyche								
(Ceratopsyche) sp.1	13	11	1	11	36	7	90	54
(Ceratopsyche) sp.2	0	0	1	5	6	1	15	24
(Hydropsyche) sp.1	11	11	4	11	37	8	93	35
TOTAL NUMBER	185	131	54	118	488	100	1220	538
TOTAL TAXA	13	23	13	21	31		18	5
S.W. DIVERSITY	3.01	3.63	2.86	3.83	3.65		3.33	0.47
EQUITABILITY	0.87	0.78	0.78	0.98	0.59		0.85	0.10
BIOTIC INDEX					2.04			
BIOT. COND. INDEX					81			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION:	7 (Clark Fork River below Warm Springs Ck)
DATE:	August 11, 1986
SAMPLE TYPE:	modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						9	795	
unassoc. chiron pupa	5	3	0	2	10	0	25	21
Antocha sp.	36	21	13	7	77	2	193	126
Atherix pachypus	3	2	2	4	11	0	28	10
Cardiocladius sp.	4	0	4	1	9	0	23	21
Cricotopus								
(C.) trifascia gp	0	1	0	0	1	0	3	5
(C.) tremelus gp	2	0	0	0	2	0	5	10
(C.)/Orthocladius (O)	2	1	0	0	3	0	8	10
(N.) nostocladius gp	7	3	4	1	15	0	38	25
Hexatoma sp.	1	0	5	1	7	0	18	22
Micropsectra sp.	1	0	0	1	2	0	5	6
Orthocladius (O.) sp	4	1	1	0	6	0	15	17
Odontomesa sp.	0	1	0	0	1	0	3	5
Pagastia sp.	5	4	3	2	14	0	35	13
Paraphaenocladius sp	0	1	0	1	2	0	5	6
Rheotanytarsus sp.	0	1	1	0	2	0	5	6
Simulium sp.	3	4	61	69	137	4	343	357
Tvetenia spp.	1	5	6	7	19	1	48	26
EPHEMEROPTERA						7	610	
Baetis tricaudatus	103	34	39	67	243	7	608	317
Drunella doddsi	0	0	0	1	1	0	3	5
COLEOPTERA						12	1040	
Cleptelmis ornata	0	0	0	1	1	0	3	5
Optioservus								
quadrimaculatus	185	31	120	35	371	11	928	739
divergins/pecosensis	10	2	5	1	18	1	45	40
Zaitzevia parva	14	6	1	5	26	1	65	54
PLECOPTERA						10	865	
Skwala sp.	16	2	7	8	33	1	83	58
Hesperoperla								
pacifica	15	3	15	3	36	1	90	69
Pteronarcella badia	107	46	81	43	277	8	693	305

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 7 (CONCLUDED)

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
TRICHOPTERA						60	5105	
Cheumatopsyche spp.	130	38	58	47	273	8	683	420
Hydropsyche								
(Ceratopsyche) sp.1	99	45	58	55	257	8	643	238
(Ceratopsyche) sp.2	9	9	21	5	44	1	110	69
(Hydropsyche) spp.	524	230	214	488	1456	43	3640	1648
Hydroptila sp.	3	1	0	0	4	0	10	14
Helicopsyche borealis	0	2	0	0	2	0	5	10
Oecetis sp.	4	1	0	1	6	0	15	17
MEGALOPTERA								
Sialis sp.	1	0	0	0	1	0	3	5
AMPHIPODA								
Hyallela azteca	4	1	3	1	9	0	23	15
GASTROPODA								
Gyraulus sp.	1	0	0	0	1	0	3	5
OLIGOCHAETA								
Tubificidae	0	6	1	4	11	0	28	28
TOTAL NUMBER	1299	505	723	861	3388	100	8470	3351
TOTAL TAXA	28	28	23	26	37		26	2
S.W. DIVERSITY	2.91	2.94	3.23	2.43	2.97		2.88	0.33
EQUITABILITY	0.38	0.38	0.58	0.28	0.43		0.41	0.13
BIOTIC INDEX					2.66			
BIOT. COND. INDEX					55			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 8 (Clark Fork River @ Dempsey)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
DIPTERA						9	548	
unassoc. chiron pupa	0	1	0	1	2	0	5	6
Antocha sp.	12	32	18	28	90	4	225	91
Atherix pachypus	12	21	18	43	94	4	235	135
Cricotopus								
(C.) tremelus gp	0	2	0	0	2	0	5	10
(N.) nostocladius gp	0	3	2	0	5	0	13	15
Hexatoma sp.	1	0	1	3	5	0	13	13
Micropsectra sp.	0	1	0	0	1	0	3	5
Microtendipes sp.	0	0	0	1	1	0	3	5
Orthocladius (O.)sp.	0	0	0	3	3	0	8	15
Nanocladius sp.	0	1	0	1	2	0	5	6
Pagastia sp.	0	0	2	5	7	0	18	24
Pentaneura sp.	1	0	1	0	2	0	5	6
Simulium sp.	0	1	0	1	2	0	5	6
Tipula sp.	0	0	1	0	1	0	3	5
Tvetenia sp.	0	0	1	1	2	0	5	6
EPHEMEROPTERA						10	593	
Baetis insignificans	0	0	1	0	1	0	3	5
Baetis tricaudatus	13	35	157	8	213	9	533	702
Tricorythodes minutus	2	6	6	9	23	1	58	29
COLEOPTERA						12	695	
Cleptelmis ornata	0	1	0	3	4	0	10	14
Oreodytes sp. 1	1	3	1	0	5	0	13	13
Optioservus								
quadrimaculatus/spp	24	71	60	79	234	10	585	243
divergins/pecosensis	0	3	1	4	8	0	20	18
Zaitzevia parva	2	9	14	2	27	1	68	59
PLECOPTERA						8	463	
Isogenoides sp.	0	5	2	1	8	0	20	22
Pteronarcella badia	1	1	9	2	13	1	33	39
Skwala sp.	22	46	51	45	164	7	410	129

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 8 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
TRICHOPTERA						61	3568	
Cheumatopsyche spp.	0	0	5	8	13	1	33	39
Hydropsyche								
(Ceratopsyche) sp.1	17	96	93	94	300	13	750	387
(Ceratopsyche) sp.2	0	19	12	28	59	3	148	118
(Hydropsyche) spp.	112	270	329	323	1034	44	2585	1012
Hydroptila sp.	0	2	2	3	7	0	18	13
Oecetis sp.	8	1	2	3	14	1	35	31
MEGALOPTERA								
Sialis sp.	0	0	0	2	2	0	5	10
OLIGOCHAETA								
Tubificidae	1	0	5	2	8	0	20	22
AMPHIPODA								
Hyallela azteca	0	0	0	1	1	0	3	5
TOTAL NUMBER	229	630	794	704	2357	100	5893	2494
TOTAL TAXA	15	22	25	27	35		22	5
S.W. DIVERSITY	2.59	2.79	2.74	2.79	2.87		2.73	0.10
EVENESS	0.66	0.63	0.59	0.59	0.56		0.62	0.04
EQUITABILITY	0.55	0.44	0.37	0.36	0.34		0.43	0.09
BIOTIC INDEX					2.62			
BIOT. COND. INDEX					58			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 9 (Clark Fork River @ Deer Lodge)
DATE: August 21,1986
SAMPLE TYPE: modified hess

		SAMPLE #			SUM	%RA	MEAN	STAND
TAXON	A	B	C*	D			#/m2	DEV
DIPTERA						9	1208	
unassoc. chiron pupa	0	1	0	0	1	0	3	5
Antocha sp.	12	8	38	9	67	1	168	143
Atherix pachypus	16	19	22	7	64	1	160	65
Cardiocladius sp.	0	3	0	0	3	0	8	15
Corynoneura sp.	0	0	0	2	2	0	5	10
Cricotopus								
(C.)/Orthocladius	3	3	4	8	18	0	45	24
(C.) trifascia gp	4	0	0	7	11	0	28	34
(C.) tremelus gp	1	0	0	0	1	0	3	5
(N.) nostocladius gp	3	2	4	4	13	0	33	10
Hexatoma sp.	4	8	8	13	33	1	83	37
Micropsectra sp.	1	0	6	3	10	0	25	26
Nanocladius sp.	1	0	0	0	1	0	3	5
Pagastia sp.	0	2	2	2	6	0	15	10
Paraphaenocladius sp	0	1	4	3	8	0	20	18
Polypedilum sp.	1	0	0	1	2	0	5	6
Pentaneura sp.	0	0	2	1	3	0	8	10
Simulium spp.	29	118	18	48	213	4	533	449
Palpomyia complex	0	0	2	0	2	0	5	10
Tvetenia spp.	2	0	12	11	25	0	63	61
EPHEMEROPTERA						11	1610	
Baetis insignificans	9	2	4	3	18	0	45	31
Baetis tricaudatus	153	115	274	74	616	11	1540	863
Tricorythodes minutus	4	1	4	1	10	0	25	17
COLEOPTERA						4	513	
Hydrophilus sp.	0	0	2	0	2	0	5	10
Optioservus								
quadrimaculatus	15	13	52	86	166	3	415	347
divergins/pecosensis	3	1	0	9	13	0	33	40
Zaitzevia parva	2	1	4	17	24	0	60	74
PLECOPTERA						2	328	
Claassinia sabulosa	0	0	0	1	1	0	3	5
Isogenoides sp.	9	7	16	12	44	1	110	39
Pteronarcella badia	0	10	4	8	22	0	55	44
Skwala sp.	5	16	30	13	64	1	160	104

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 9 (CONCLUDED)

TAXON	SAMPLE # A	B	C*	D	SUM	%RA	MEAN #/m2	STAND DEV
TRICHOPTERA						74	10433	
Brachycentrus sp.	1	0	0	0	1	0	3	5
Cheumatopsyche spp.	0	0	0	1	1	0	3	5
Glossosoma sp.	0	0	0	1	1	0	3	5
Hydropsyche								
(Ceratopsyche) sp.1	18	9	18	16	61	1	153	43
(Hydropsyche) spp.	594	764	1910	836	4104	73	10260	5980
Oecetis sp.	0	1	2	0	3	0	8	10
Hydroptila sp.	1	1	0	0	2	0	5	6
ODONATA								
Ophiogomphus sp.	0	1	0	0	1	0	3	5
OLIGOCHAETA								
Tubificidae	1	0	0	0	1	0	3	5
TOTAL NUMBER	892	1107	2442	1197	5638	100	14095	7001
TOTAL TAXA	25	23	24	28	39		25	2
S.W. DIVERSITY	1.87	1.74	1.37	1.97	1.72		1.74	0.26
EQUITABILITY	0.19	0.19	0.13	0.18	0.11		0.17	0.03
BIOTIC INDEX					2.92			
BIOT. COND. INDEX					53			

* sample C was subsampled (2/4ths).

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 10 (CFR above the L. Blackfoot R)
DATE: August 21, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C*	D*			#/m2	DEV
DIPTERA						28	8773	
unassoc. chiron pupa	2	1	6	20	29	0	73	88
Antocha sp.	1	0	4	4	9	0	23	21
Cardiocladius sp.	2	4	14	40	60	0	150	175
Cricotopus								
/Orthocladius (O)	3	8	2	8	21	0	53	32
(C.) trifascia gp	12	44	44	64	164	1	410	215
(C.) nostococladius	21	41	88	88	238	2	595	339
Eukiefferiella cla	0	0	4	0	4	0	10	20
Hexatonma sp.	34	8	0	0	42	0	105	161
Micropsectra sp.	10	0	2	0	12	0	30	48
Nanocladius sp.	0	1	0	0	1	0	3	5
Orthocladius sp.	1	0	2	0	3	0	8	10
Paraphaenocladius sp	23	12	34	20	89	1	223	91
Pentaneura sp.	6	4	0	0	10	0	25	30
Polypedilum sp.	11	0	6	8	25	0	63	46
Rheotanytarsus sp.	0	1	2	0	3	0	8	10
Simulium spp.	48	237	960	1408	2653	21	6633	6332
Tvetenia sp.	15	43	22	66	146	1	365	230
EPHEMEROPTERA						9	2803	
Baetis bicaudatus	2	4	2	8	16	0	40	28
Baetis insignificans	2	0	2	0	4	0	10	12
Baetis tricaudatus	246	189	290	296	1021	8	2553	495
Tricorythodes minutus	47	8	2	20	77	1	193	200
Psuedocloeon sp.	0	1	2	0	3	0	8	10
COLEOPTERA						1	288	
Optioservus								
quadrimaculatus	12	25	30	16	83	1	208	82
divergins/pecosensis	5	7	2	0	14	0	35	31
Zaitzevia parva	0	8	6	4	18	0	45	34
PLECOPTERA						2	550	
Skwala sp.	1	7	12	4	24	0	60	47
Isogenoides sp.	25	79	26	28	158	1	395	264
Pteronarcella badia	0	0	18	20	38	0	95	110

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 10 (Concluded)

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C*	D*			#/m2	DEV
TRICHOPTERA						60	18888	
Agapetus sp.	0	1	0	0	1	0	3	5
Arctopsyche grandis	0	2	0	0	2	0	5	10
Cheumatopsyche spp.	59	56	76	72	263	2	658	97
Hydropsyche								
(Ceratopsyche) sp.1	16	14	58	20	108	1	270	208
(Hydropsyche) spp.	872	1360	2348	2544	7124	57	17810	7973
Hydroptila sp.	2	40	10	0	52	0	130	185
Oecetis sp.	1	3	0	0	4	0	10	14
Psychomyia flavida	1	0	0	0	1	0	3	5
ODONATA								
Ophiogomphus sp.	1	0	2	0	3	0	8	10
TOTAL NUMBER	1481	2208	4076	4758	12523	100	31308	15400
TOTAL TAXA	28	27	29	20	37		26	4
S.W. DIVERSITY	2.41	2.35	2.10	2.05	2.16		2.13	0.17
EQUITABILITY	0.24	0.23	0.18	0.25	0.16		0.23	0.03
BIOTIC INDEX					2.97			
BIOT. COND. INDEX					50			

* samples C (2/4ths) and D (2/8ths) were subsampled.

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 11 (CFR @ Gold Creek)
DATE: August 21,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A*	B	C*	D*			#/m2	DEV
DIPTERA						33	2803	
unassoc. chiron pupa	16	0	10	4	30	1	75	70
Antocha sp.	20	3	8	12	43	1	108	72
Atherix pachypus	8	3	0	4	15	0	38	33
Cardiocladius sp.	4	0	2	8	14	0	35	34
Corynonuera sp.	0	0	2	0	2	0	5	10
Cricotopus								
(C.) trifascia gp	0	7	0	20	27	1	68	94
(N.) nostococladius	12	0	8	36	56	2	140	155
Hexatoma sp.	8	7	0	20	35	1	88	83
Pentaneura sp.	4	0	0	0	4	0	10	20
Nanocladius sp.	4	0	0	4	8	0	20	23
Eukiefferiella sp. claripennis gp	0	0	0	4	4	0	10	20
Limnophora sp.	0	0	10	0	10	0	25	50
Micropsectra sp.	0	1	4	0	5	0	13	19
Microtendipes pedellus gp	0	3	0	0	3	0	8	15
Orthocladius								
(Orthocladius)	0	0	0	4	4	0	10	20
(Eudactocladius)	0	0	0	4	4	0	10	20
Parametriocnemus sp.	0	0	4	4	8	0	20	23
Paraphaenocladius sp.	40	1	6	16	63	2	158	173
Polypedilum sp.	8	3	14	20	45	1	113	74
Rheotanytarsus sp.	4	1	4	0	9	0	23	21
Simulium spp.	16	150	0	500	666	20	1665	2323
Palpomyia complex	0	1	0	0	1	0	3	5
Thienemannimyia sp.	0	0	0	4	4	0	10	20
Tvetenia spp.	20	5	4	32	61	2	153	134
EPHEMEROPTERA						26	2143	
Attenella margarita	12	6	0	0	18	1	45	57
Baetis bicaudatus	16	3	0	12	31	1	78	75
Baetis insignificans	8	3	2	16	29	1	73	64
Baetis tricaudatus	112	54	144	52	362	11	905	452
Drunella grandis	4	0	0	0	4	0	10	20
Rhithrogena sp.	0	1	2	0	3	0	8	10
Tricorythodes minutus	68	190	68	84	410	12	1025	588

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 11 (Concluded)

TAXON	SAMPLE # A*	B	C*	D*	SUM	%RA	MEAN #/m2	STAND DEV
COLEOPTERA						1	115	
Optioservus								
divergins/pecosensis	8	4	2	16	30	1	75	62
quadrimaculatus	8	0	0	4	12	0	30	38
Zaitzevia parva	0	0	4	0	4	0	10	20
PLECOPTERA						6	528	
Chloroperlinae	12	0	0	4	16	0	40	57
Hesperoperla pacifica	4	0	0	4	8	0	20	23
Isogenoides sp.	24	10	46	72	152	5	380	271
Pteronarcella badia	16	0	0	8	24	1	60	77
Skwala sp.	0	3	0	8	11	0	28	38
TRICHOPTERA						33	2795	
Arctopsyche grandis	24	1	4	4	33	1	83	106
Brachycentrus occidentalis	0	0	0	4	4	0	10	20
Cheumatopsyche spp.	4	0	0	4	8	0	20	23
Hydropsyche								
(Ceratopsyche) sp.1	72	10	4	68	154	5	385	365
(Hydropsyche) spp.	412	80	30	252	774	23	1935	1740
Hydroptila sp.	64	16	24	12	116	3	290	239
Ochrotrichia sp.	4	2	0	4	10	0	25	19
Oecetis sp.	0	3	2	4	9	0	23	17
Psychomyia flavida	0	0	10	0	10	0	25	50
HYDRACARINA	0	1	0	0	1	0	3	5
TOTAL NUMBER	1036	572	418	1328	3354	100	8385	4189
TOTAL TAXA	30	28	24	35	49		29	5
S.W. DIVERSITY	3.41	2.89	3.26	3.34	3.71		3.23	0.23
EVENESS	0.69	0.60	0.71	0.65	0.66		0.66	0.05
EQUITABILITY	0.51	0.37	0.57	0.41	0.39		0.47	0.09
BIOTIC INDEX					2.72			
BIOT. COND. INDEX					59			

* samples A (2/8ths), C (2/4ths) and D (2/8ths) were subsampled.

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION:	12 (CFR @ Bonita)
DATE:	August 21,1986
SAMPLE TYPE:	modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
DIPTERA						13	1268	
unassoc. chiron pupa	0	1	1	0	2	0	5	6
Antocha sp.	0	0	0	1	1	0	3	5
Atherix pachypus	94	64	53	50	261	7	653	201
Cardiocladius sp.	0	0	1	1	2	0	5	6
Cricotopus								
/Orthocladius	2	2	1	0	5	0	13	10
(C.) trifascia gp	3	6	1	0	10	0	25	26
(N.) nostococladius	0	0	0	6	6	0	15	30
Eukiefferiella								
gracei gp	0	0	1	1	2	0	5	6
Hexatoma sp.	6	2	19	2	29	1	73	81
Micropsectra sp.	1	1	0	0	2	0	5	6
Microtendipes								
pedellus gp	0	1	1	0	2	0	5	6
Orthocladius								
(Orthocladius)	1	1	0	0	2	0	5	6
(Eudactoclacdius)	1	2	6	0	9	0	23	26
Paraphaenocladius sp	1	1	0	0	2	0	5	6
Potthastia gaedi gp	0	3	1	0	4	0	10	14
Polypedilum sp.	12	23	18	7	60	2	150	70
Protanyderus sp.	0	0	1	0	1	0	3	5
Simulium sp.	19	3	5	24	51	1	128	103
Thienemannimyia sp.	0	6	1	1	8	0	20	27
Tvetenia spp.	10	13	6	19	48	1	120	55
EPHEMEROPTERA						18	1710	
Attenella margarita	1	0	0	1	2	0	5	6
Baetis bicaudatus	1	7	4	2	14	0	35	26
Baetis insignificans	5	10	9	4	28	1	70	29
Baetis tricaudatus	171	114	137	163	585	15	1463	259
Ephemerella								
infrequens/inermis	0	0	0	1	1	0	3	5
Psuedocloeon sp.	6	10	2	0	18	0	45	44
Rhithrogena sp.	1	2	0	0	3	0	8	10
Tricorythodes								
minutus	4	12	14	3	33	1	83	56
COLEOPTERA						2	220	
Optioservus								
quadrimaculatus	7	8	2	0	17	0	43	39
divergins/pecosensis	4	7	4	2	17	0	43	21
Zaitzevia parva	15	16	9	14	54	1	135	31

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 12 (Concluded)

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
PLECOPTERA						3	248	
Claassinia sabulosa	1	1	0	0	2	0	5	6
Isogenoides sp.	37	31	21	8	97	3	243	127
TRICHOPTERA						64	6040	
Arctopsyche grandis	4	1	1	3	9	0	23	15
Cheumatopsyche spp.	2	3	7	1	13	0	33	26
Hydropsyche								
(Ceratopsyche) sp.1	13	3	2	20	38	1	95	86
(Hydropsyche) spp.	692	348	555	711	2306	61	5765	1674
Hydroptila sp.	0	1	1	0	2	0	5	6
Oecetis sp.	2	16	20	9	47	1	118	79
Psychomyia flavida	1	0	0	0	1	0	3	5
TOTAL NUMBER	1117	719	904	1054	3794	100	9485	1772
TOTAL TAXA	29	31	29	24	40		28	3
S.W. DIVERSITY	2.10	2.85	2.22	1.83	2.27		2.25	0.43
EQUITABILITY	0.19	0.32	0.22	0.19	0.16		0.23	0.06
BIOTIC INDEX					2.84			
BIOT. COND. INDEX					57			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 13 (CFR @ Turah)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B*	C*	D*			#/m2	DEV
DIPTERA						39	6040	
unassoc. chiron pupa	9	54	40	22	125	2	313	198
Antocha sp.	2	4	4	0	10	0	25	19
Atherix pachypus	6	40	0	2	48	1	120	188
Cardiocladius sp.	43	68	134	48	293	5	733	419
Cricotopus (C.) trifascia gp	36	86	298	200	620	10	1550	1175
/Orthocladius	1	0	10	0	11	0	28	49
(N.) Nostococladius	0	0	6	14	20	0	50	66
Hexatoma sp.	19	40	16	18	93	2	233	112
Micropsectra sp.	10	2	4	14	30	0	75	55
Microtendipes pedellus gp	1	18	0	0	19	0	48	88
Orthocladius sp. (Eudactocladius)	0	0	0	2	2	0	5	10
Pagastia sp.	2	0	2	0	4	0	10	12
Paraphaenocladius sp	0	2	0	0	2	0	5	10
Phaenopsectra sp.	0	0	2	0	2	0	5	10
Polypedilum sp.	195	346	256	86	883	14	2208	1092
Rheotanytarsus sp.	0	8	2	10	20	0	50	48
Simulium sp.	39	22	76	26	163	3	408	246
Thienemannimyia gp.	2	14	4	10	30	0	75	55
Tvetenia sp.	5	14	6	16	41	1	103	56
EPHEMEROPTERA						10	1550	
Attenella margarita	15	10	4	12	41	1	103	46
Baetis bicaudatus	1	2	2	8	13	0	33	32
Baetis insignificans	5	6	12	2	25	0	63	42
Baetis tricaudatus	42	50	52	34	178	3	445	82
Drunella grandis	5	12	6	2	25	0	63	42
Ephemerella infrequens/inermis	0	0	2	0	2	0	5	10
Psuedocloeon sp.	2	6	2	8	18	0	45	30
Rhithrogena sp.	1	0	0	0	1	0	3	5
Seratella tibialis	7	0	0	0	7	0	18	35
Tricorythodes minutus	24	92	62	132	310	5	775	458
COLEOPTERA						4	600	
Optioservus quadrimaculatus	4	18	6	2	30	0	75	72
divergins/pecosensis	6	30	10	38	84	1	210	154
Zaitzevia parva	18	36	38	34	126	2	315	91

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 14 (Blackfoot River)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						25	160	
unassoc. chiron pupa	0	0	1	1	2	1	5	6
Antocha sp.	0	2	0	0	2	1	5	10
Cardiocladius sp.	0	1	0	0	1	0	3	5
Cricotopus (C.) trifascia gp	0	3	0	1	4	2	10	14
Eukiefferiella coerulescens gp	0	0	0	1	1	0	3	5
Hexatoma sp.	2	3	2	1	8	3	20	8
Micropsectra sp.	17	16	6	3	42	16	105	70
Polypedilum sp.	0	0	0	1	1	0	3	5
Simulium sp.	0	0	1	0	1	0	3	5
Thienemanniella sp.	0	0	0	1	1	0	3	5
Tanytarsus sp.	0	1	0	0	1	0	3	5
EPHEMEROPTERA						25	163	
Baetis insignificans	4	7	5	5	21	8	53	13
Baetis tricaudatus	1	5	1	4	11	4	28	21
Drunella grandis	0	3	2	0	5	2	13	15
Epeorus longimanus	1	1	2	2	6	2	15	6
Ephemerella infrequens/inermis	1	0	0	0	1	0	3	5
Seratella tibialis	2	2	8	5	17	7	43	29
Rhithrogena sp.	2	0	1	0	3	1	8	10
Tricorythodes minutus	0	1	0	0	1	0	3	5
COLEOPTERA						10	68	
Optioservus quadrimaculatus	0	0	3	5	8	3	20	24
divergins/pecosensis	3	2	0	1	6	2	15	13
Zaitzevia parva	10	0	3	0	13	5	33	47
PLECOPTERA						15	95	
Doroneuria theodora	8	3	5	7	23	9	58	22
Pteronarcella badia	0	0	1	0	1	0	3	5
Pteronarcys californica	2	1	2	1	6	2	15	6
Skwala sp.	0	1	0	0	1	0	3	5
Sweltsa sp.	4	2	1	0	7	3	18	17

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 14 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
TRICHOPTERA						22	145	
Arctopsyche grandis	3	1	5	3	12	5	30	16
Cheumatopsyche spp.	0	1	0	0	1	0	3	5
Dicosmoecus sp.	0	0	0	1	1	0	3	5
Helicopsyche borealis	3	1	0	0	4	2	10	14
Hydropsyche								
(Ceratopsyche) sp.1	5	4	3	3	15	6	38	10
(Hydropsyche) sp.1	4	7	7	1	19	7	48	29
Luecotrichia sp. 1	1	0	2	0	3	1	8	10
Psychomyia flavida	0	2	0	0	2	1	5	10
Wormaldia sp.	0	0	1	0	1	0	3	5
MOLLUSCA						1	5	
Physa sp.	2	0	0	0	2	1	5	10
Pisidium sp.	0	0	2	0	2	1	5	10
OLIGOCHAETA								
Lumbricidae	1	0	0	1	2	1	5	6
TURBELLARIA	2	0	0	0	2	1	5	10
TOTAL NUMBER	78	70	64	48	260	100	650	127
TOTAL TAXA	21	23	21	19	40		21	2
S.W. DIVERSITY	3.87	3.96	4.07	3.88	4.43		3.94	0.09
EVENESS	0.88	0.88	0.93	0.91	0.83		0.90	0.02
EQUITABILITY	1.01	0.99	1.17	1.13	0.80		1.08	0.09
BIOTIC INDEX					2.09			
BIOT. COND. INDEX					71			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 15 (CFR below Milltown Dam)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						38	5368	
unassoc. chiron pupa	262	66	9	18	355	6	888	1182
Antocha sp.	1	2	13	6	22	0	55	54
Atherix pachypus	0	1	2	0	3	0	8	10
Cardiocladius spp.	145	150	10	78	383	7	958	659
Chelifera sp.	0	1	0	0	1	0	3	5
Cricotopus								
(C.) tremelus gp	0	0	0	1	1	0	3	5
(C.) trifascia gp	341	222	5	79	647	11	1618	1496
(N.) nostococladius gp	0	2	0	0	2	0	5	10
/Orthocladius	7	0	1	0	8	0	20	34
Eukiefferiella								
gracei gp	6	2	0	1	9	0	23	26
Micropsectra sp.	2	1	3	1	7	0	18	10
Microtendipes sp.	26	10	5	3	44	1	110	104
Nanocladius sp.	0	1	0	0	1	0	3	5
Orthocladius sp.								
(Orthocladius) sp.	0	0	1	1	2	0	5	6
Pagastia sp.	1	3	8	2	14	0	35	31
Parametriocnemus sp.	0	1	0	0	1	0	3	5
Phaenopsectra sp.	0	1	0	0	1	0	3	5
Polypedilum sp.	192	241	12	53	498	9	1245	1094
Rheotanytarsus sp.	2	3	2	0	7	0	18	13
Simulium sp.	22	21	4	33	80	1	200	120
Tvetenia sp.	9	47	2	3	61	1	153	214
EPHEMEROPTERA						7	988	
Attenella margarita	2	0	0	0	2	0	5	10
Baetis bicaudatus	1	1	0	0	2	0	5	6
Baetis insignificans	21	17	49	17	104	2	260	154
Baetis tricaudatus	24	69	14	21	128	2	320	250
Drunella grandis	48	48	19	10	125	2	313	197
Drunella doddsi	0	1	0	1	2	0	5	6
Psuedocloeon sp.	0	0	4	1	5	0	13	19
Seratella tibialis	2	11	9	4	26	0	65	42
Tricorythodes minutus	0	0	1	0	1	0	3	5
COLEOPTERA						3	410	
Cleptelmis ornata	1	0	1	0	2	0	5	6
Optioservus								
quadrimaculatus	24	5	0	1	30	1	75	112
divergins/pecosensis	12	36	5	11	64	1	160	137
Zaitzevia parva	24	22	9	13	68	1	170	72

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 15 (Concluded)

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
PLECOPTERA						6	838	
Chloroperlinae	1	0	0	0	1	0	3	5
Claassinia sabulosa	0	1	0	1	2	0	5	6
Hesperoperla pacifica	22	15	1	2	40	1	100	102
Isogenoides sp.	6	16	6	23	51	1	128	83
Pteronarcella badia	99	64	9	9	181	3	453	442
Pteronarcys californica	20	17	5	17	59	1	148	67
Skwala sp.	0	0	0	1	1	0	3	5
TRICHOPTERA						46	6610	
Arctopsyche grandis	8	4	14	5	31	1	78	45
Brachycentrus occidentalis	0	1	1	4	6	0	15	17
Cheumatopsyche spp.	162	75	99	77	413	7	1033	406
Hydropsyche								
(Ceratopsyche) sp.1	755	413	291	290	1749	31	4373	2196
(Hydropsyche) sp.1	77	80	103	91	351	6	878	118
Ochrotrichia sp.	12	33	0	7	52	1	130	142
Oecetis sp.	0	1	0	0	1	0	3	5
Psychomyia flavida	3	3	12	19	37	1	93	78
Rhyacophila sp. 1	1	2	0	0	3	0	8	10
Wormaldia sp.	0	1	0	0	1	0	3	5
LEPIDOPTERA						1	78	
Petrophila sp.	12	0	6	13	31	1	78	60
TURBELLARIA	0	0	0	4	4	0	10	20
TOTAL NUMBER	2353	1711	735	921	5720	100	14300	7468
TOTAL TAXA	35	41	33	36	53		36	3
S.W. DIVERSITY	3.26	3.67	3.21	3.62	3.60		3.44	0.24
EQUITABILITY	0.39	0.45	0.40	0.49	0.33		0.43	0.05
BIOTIC INDEX					2.85			
BIOT. COND. INDEX					52			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 16 (CFR above Missoula WWTP)
DATE: August 12, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
DIPTERA						13	900	
unassoc. chiron pupa	1	0	0	1	2	0	5	6
Antocha sp.	0	1	1	0	2	0	5	6
Atherix pachypus	0	6	2	5	13	0	33	28
Cardiocladius spp.	7	9	11	10	37	1	93	17
Cricotopus								
(C.) trifascia gp	0	7	3	1	11	0	28	31
(N.) nostococladius	1	0	1	0	2	0	5	6
/Orthocladius	2	7	0	0	9	0	23	33
Microtendipes sp.	0	1	0	6	7	0	18	29
Pagastia sp.	0	0	1	0	1	0	3	5
Polypedilum sp.	2	24	21	19	66	2	165	99
Rheotanytarsus sp.	1	3	1	0	5	0	13	13
Simulium sp.	139	2	26	1	168	6	420	657
Stilobezzini gp	0	0	1	5	6	0	15	24
Tvetenia sp.	2	2	10	17	31	1	78	72
EPHEMEROPTERA						7	463	
Baetis insignificans	6	36	7	52	101	4	253	226
Baetis tricaudatus	12	1	34	21	68	2	170	140
Drunella grandis	3	0	3	2	8	0	20	14
Drunella doddsi	0	0	0	3	3	0	8	15
Seratella tibialis	3	1	0	0	4	0	10	14
Tricorythodes minutus	0	0	0	1	1	0	3	5
COLEOPTERA						2	123	
Optioservus								
quadrimaculatus	1	0	3	2	6	0	15	13
divergins/pecosensis	1	1	4	10	16	1	40	42
Zaitzevia parva	2	2	1	22	27	1	68	102
PLECOPTERA						1	80	
Doroneuria theodora	3	0	0	0	3	0	8	15
Hesperoperla pacifica	1	0	1	0	2	0	5	6
Isogenoides sp.	0	3	4	0	7	0	18	21
Pteronarcella badia	1	0	1	7	9	0	23	32
Pteronarcys californica	2	2	3	4	11	0	28	10

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 16 (Concluded)

	SAMPLE #				SUM	%RA	MEAN	STAND
TAXON	A	B	C	D			#/m2	DEV
TRICHOPTERA						76	5235	
Arctopyche grandis	9	6	24	17	56	2	140	81
Brachycentrus occidentalis	1	1	0	0	2	0	5	6
Cheumatopsyche spp.	52	45	81	157	335	12	838	513
Hydropsyche								
(Ceratopsyche) spp	301	133	349	514	1297	47	3243	1568
(Hydropsyche) spp	73	66	121	70	330	12	825	258
Hydroptila sp.	0	3	0	2	5	0	13	15
Luecotrichia sp.	0	0	0	1	1	0	3	5
Psychomyia flavida	3	44	1	17	65	2	163	198
Rhyacophila								
acropedes/vao	0	0	1	0	1	0	3	5
sp. 1	0	0	1	0	1	0	3	5
Wormaldia sp.	0	0	0	1	1	0	3	5
LEPIDOPTERA						2	115	
Petrophila sp.	0	19	6	21	46	2	115	101
ODONATA								
Ophiogomphus sp.	0	0	0	1	1	0	3	5
OLIGOCHAETA								
Enchytraeidae	2	0	0	0	2	0	5	10
TURBELLARIA	1	0	0	0	1	0	3	5
TOTAL NUMBER	632	425	723	990	2770	100	6925	2343
TOTAL TAXA	27	26	30	29	44		28	2
S.W. DIVERSITY	2.52	3.40	2.89	2.89	3.12		2.93	0.36
EQUITABILITY	0.27	0.58	0.30	0.32	0.29		0.37	0.14
BIOTIC INDEX					2.86			
BIOT. COND. INDEX					50			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 18 (CFR @ Shuffields)
DATE: August 12, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
DIPTERA						10	580	
unassoc. chiron pupa	0	1	0	7	8	0	20	34
Antocha sp.	0	0	1	0	1	0	3	5
Atherix pachypus	0	1	0	2	3	0	8	10
Cardiocladius spp.	1	10	4	12	27	1	68	51
Cricotopus								
(C.) trifascia gp	0	1	0	5	6	0	15	24
/Orthocladius (O.	0	0	0	3	3	0	8	15
Eukiefferiella								
brehmi gp	0	0	0	1	1	0	3	5
claripennis gp	0	1	0	1	2	0	5	6
Micropsectra sp.	1	2	3	3	9	0	23	10
Microtendipes sp.	0	0	0	1	1	0	3	5
Hexatoma sp.	1	2	1	1	5	0	13	5
Orthocladius sp.								
(Orthocladius) sp.	1	6	0	7	14	1	35	35
Pagastia sp.	0	1	1	1	3	0	8	5
Polypedilum sp.	18	37	22	45	122	5	305	127
Potthastia gaedi gp	1	0	0	0	1	0	3	5
Rheotanytarsus sp.	0	3	2	6	11	0	28	25
Simulium sp.	0	1	0	1	2	0	5	6
Stillobezzini gp	0	1	1	2	4	0	10	8
Thienemannimyia gp	0	0	0	1	1	0	3	5
Tvetenia sp.	0	1	2	5	8	0	20	22
EPHEMEROPTERA						9	498	
Attenella margarita	1	0	0	0	1	0	3	5
Baetis insignificans	19	18	15	15	67	3	168	21
Baetis tricaudatus	18	21	36	15	90	4	225	93
Drunella grandis	1	2	0	0	3	0	8	10
Drunella doddsi	0	1	0	1	2	0	5	6
Psuedocloeon sp.	1	0	3	0	4	0	10	14
Seratella tibialis	2	1	4	0	7	0	18	17
Epeorus albertae	0	1	0	0	1	0	3	5
Rhithrogena hageni	4	3	1	2	10	0	25	13
Tricorythodes minutus	1	2	1	10	14	1	35	44
COLEOPTERA						0	28	
Zaitzevia parva	0	5	3	0	8	0	20	24
Optioservus								
quadrimaculatus	1	0	0	0	1	0	3	5
divergins/pecosensis	1	0	1	0	2	0	5	6

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 18 (Concluded)

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
PLECOPTERA						4	215	
Doroneuria theodora	0	1	0	0	1	0	3	5
Hesperoperla pacifica	0	3	0	1	4	0	10	14
Isogenoides sp.	22	11	11	22	66	3	165	64
Pteronarcella badia	0	1	5	1	7	0	18	22
Pteronarcys californica	0	4	0	0	4	0	10	20
Skwala sp.	1	0	2	1	4	0	10	8
TRICHOPTERA						76	4453	
Arctopsyche grandis	4	14	27	7	52	2	130	102
Brachycentrus occidentalis	0	1	1	0	2	0	5	6
Cheumatopsyche spp.	30	97	218	137	482	21	1205	786
Hydropsyche								
(Ceratopsyche) spp	105	276	343	194	918	39	2295	1029
(Hydropsyche) spp.	7	88	117	87	299	13	748	473
Oecetis sp.	0	0	0	2	2	0	5	10
Psychomyia flavida	0	3	6	14	23	1	58	60
Wormaldia sp.	0	1	0	0	1	0	3	5
Zumatrichia sp.	0	0	2	0	2	0	5	10
LEPIDOPTERA						1	60	
Petrophila sp.	0	3	11	10	24	1	60	54
OLIGOCHAETA								
Enchytraeidae	0	0	0	1	1	0	3	5
TURBELLARIA	1	0	0	0	1	0	3	5
TOTAL NUMBER	242	625	844	624	2335	100	5838	2502
TOTAL TAXA	24	36	29	34	51		30	6
S.W. DIVERSITY	2.94	2.89	2.63	3.23	3.01		2.92	0.24
EQUITABILITY	0.47	0.30	0.30	0.39	0.22		0.37	0.08
BIOTIC INDEX					2.83			
BIOT. COND. INDEX					51			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 19 (Bitterroot River)
DATE: August 12, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			#/m2	DEV
DIPTERA						19	1683	
unassoc. chiron pupa	6	9	8	40	63	2	158	162
Atherix pachypus	2	7	4	12	25	1	63	43
Cardiocladius spp.	12	16	21	47	96	3	240	158
Cricotopus								
(C.) trifascia gp	1	7	3	11	22	1	55	44
(C.) bicinctus gp.	0	0	1	0	1	0	3	5
(C.) tremelus gp	8	15	5	36	64	2	160	140
Hexatoma sp.	0	0	0	1	1	0	3	5
Micropsectra sp.	1	12	8	30	51	1	128	124
Microtendipes sp.	0	1	0	1	2	0	5	6
Nanocladius parvulus gp	0	1	0	0	1	0	3	5
Pagastia sp.	0	0	1	1	2	0	5	6
Potthastia								
longimana gp	0	0	1	0	1	0	3	5
gaedii gp	0	1	0	1	2	0	5	6
Polypedilum sp.	9	32	20	60	121	3	303	219
Rheotanytarsus sp.	7	29	16	89	141	4	353	370
Simulium sp.	2	1	17	20	40	1	100	99
Stillobezzini	1	3	2	6	12	0	30	22
Thienemannimyia gp	0	0	0	3	3	0	8	15
Tvetenia sp.	0	7	3	15	25	1	63	65
EPHEMEROPTERA						9	823	
Attenella margarita	2	7	6	16	31	1	78	59
Baetis bicaudatus	0	1	0	0	1	0	3	5
Baetis insignificans	8	30	25	73	136	4	340	277
Baetis tricaudatus	8	18	6	47	79	2	198	189
Drunella grandis	1	3	5	20	29	1	73	87
Rhithrogena sp.	0	3	0	11	14	0	35	52
Seratella tibialis	5	5	10	14	34	1	85	44
Tricorythodes								
minutus	0	3	0	2	5	0	13	15
COLEOPTERA						10	870	
Narpus concolor	0	0	0	3	3	0	8	15
Optioservus								
quadrimaculatus	8	34	15	69	126	4	315	273
divergins/pecosensi	8	35	21	67	131	4	328	254
Zaitzevia parva	10	29	15	34	88	2	220	113
PLECOPTERA						5	440	
Doroneuria theodora	0	2	0	7	9	0	23	33
Isogenoides sp.	3	0	9	17	29	1	73	75
Pteronarcella badia	4	3	17	70	94	3	235	316

Skwala sp.	4	2	7	31	44	1	110	135

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 19 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
TRICHOPTERA						56	5008	
Arctopyche grandis	5	9	10	8	32	1	80	22
Brachycentrus occidentalis	6	7	10	9	32	1	80	18
Cheumatopsyche spp.	119	164	162	120	565	16	1413	251
Glossosoma sp.	0	1	0	0	1	0	3	5
Hydropsyche								
(Ceratopsyche) sp.1	74	87	152	113	426	12	1065	344
(Hydropsyche) sp.1	89	190	238	421	938	26	2345	1390
Oecetis sp.	0	1	0	0	1	0	3	5
Zumatrichia sp.	0	6	1	1	8	0	20	27
LEPIDOPTERA								
Petrophila sp.	0	8	4	5	17	0	43	33
OLIGOCHAETA								
Lumbricidae	2	7	0	1	10	0	25	31
TURBELLARIA	1	0	1	0	2	0	5	6
TOTAL NUMBER	406	796	824	1532	3558	100	8895	4689
TOTAL TAXA	27	37	32	38	46		34	5
S.W. DIVERSITY	3.22	3.76	3.39	4.02	3.84		3.60	0.36
EQUITABILITY	0.49	0.53	0.47	0.62	0.45		0.53	0.07
BIOTIC INDEX					2.70			
BIOT. COND. INDEX					52			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 20 (CFR @ Harper) 's Bridge
DATE: August 13, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						19	1563	
unassoc. chiron pupa	1	5	3	5	14	0	35	19
Atherix pachypus	6	1	11	22	40	1	100	90
Cardiocladius spp.	8	9	17	23	57	2	143	71
Cricotopus								
(C.) bicinctus gp	0	1	0	0	1	0	3	5
(C.) tremelus gp	0	2	0	3	5	0	13	15
(C.) trifascia gp	1	6	6	5	18	1	45	24
/Orthocladius	0	4	0	0	4	0	10	20
Eukiefferiella								
claripennis gp	0	0	0	1	1	0	3	5
Hexatoma sp.	5	3	2	0	10	0	25	21
Micropsectra sp.	2	1	4	4	11	0	28	15
Nanocladius parvulus gp	0	0	1	0	1	0	3	5
Orthocladius sp.								
(Orthocladius) sp.	0	2	0	0	2	0	5	10
(Eudactocladius) sp	0	0	0	1	1	0	3	5
Polypedilum sp.	3	11	11	18	43	1	108	61
Potthastia gaedii gp	0	0	0	1	1	0	3	5
Rheotanytarsus sp.	2	15	5	9	31	1	78	56
Simulium sp.	44	13	19	301	377	12	943	1385
Stillobezzini	0	1	0	0	1	0	3	5
Thienemannimyia gp	0	1	0	0	1	0	3	5
Tvetenia sp.	0	0	1	5	6	0	15	24
EPHEMEROPTERA						20	1605	
Attenella margarita	1	8	2	4	15	0	38	31
Baetis bicaudatus	0	0	0	1	1	0	3	5
Baetis insignificans	21	79	44	72	216	7	540	267
Baetis tricaudatus	53	19	124	137	333	10	833	565
Drunella grandis	0	2	0	1	3	0	8	10
Psuedocloeon sp.	0	0	0	1	1	0	3	5
Rhithrogena hageni	2	42	3	4	51	2	128	195
Seratella tibialis	2	0	1	3	6	0	15	13
Tricorythodes minutus	0	6	2	8	16	0	40	37
COLEOPTERA						1	58	
Optioservus								
quadrimaculatus	0	4	1	1	6	0	15	17
divergins/pecosensis	2	1	2	5	10	0	25	17
Zaitzevia parva	2	0	4	1	7	0	18	17

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 20 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
PLECOPTERA						2	153	
Doroneuria theodora	4	2	1	0	7	0	18	17
Hesperoperla pacifica	0	1	0	1	2	0	5	6
Isogenoides sp.	2	7	2	3	14	0	35	24
Pteronarcella badia	11	0	10	12	33	1	83	56
Pteronarcys californica	0	0	1	4	5	0	13	19
TRICHOPTERA						58	4715	
Arctopsyche grandis	8	2	24	17	51	2	128	97
Brachycentrus occidentalis	2	10	6	10	28	1	70	38
Cheumatopsyche spp.	82	14	57	56	209	6	523	282
Glossosoma sp.	1	1	0	0	2	0	5	6
Hydropsyche								
(Ceratopsyche) sp.1	49	15	49	42	155	5	388	162
(Hydropsyche) sp.1	457	130	354	499	1440	44	3600	1650
Zumatrichia sp.	1	0	0	0	1	0	3	5
LEPIDOPTERA								
Petrophila sp.	1	0	1	0	2	0	5	6
TOTAL NUMBER	773	418	768	1280	3239	100	8098	3548
TOTAL TAXA	26	31	29	33	45		30	3
S.W. DIVERSITY	2.32	3.50	2.85	2.88	3.02		2.89	0.48
EVENESS	0.49	0.71	0.59	0.57	0.55		0.59	0.09
EQUITABILITY	0.26	0.52	0.35	0.31	0.25		0.36	0.11
BIOTIC INDEX					2.81			
BIOT. COND. INDEX					53			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 22 (CFR @ Huson)
DATE: August 13, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
DIPTERA						18	2530	
unassoc. chiron pupa	10	11	14	4	39	1	98	42
Atherix pachypus	5	10	15	17	47	1	118	54
Cardiocladius spp.	1	36	16	19	72	1	180	144
Cladotanytarsus vanderwulpi gp	1	0	0	0	1	0	3	5
Cricotopus								
(C.) bicintus gp	0	0	1	3	4	0	10	14
(C.) tremelus gp	0	0	0	2	2	0	5	10
(C.) trifascia gp	1	11	10	5	27	0	68	46
/Orthocladius	0	0	1	0	1	0	3	5
Micropsectra sp.	7	0	3	10	20	0	50	44
Nanocladius parvulus gp	0	0	1	0	1	0	3	5
Polypedilum spp.	10	22	13	8	53	1	133	62
Rheotanytarsus sp.	8	6	1	6	21	0	53	30
Simulium sp.	18	345	82	233	678	12	1695	1477
Synorthocladius sp.	0	0	1	0	1	0	3	5
Thienemannimyia gp	2	1	1	0	4	0	10	8
Tvetenia sp.	5	19	6	11	41	1	103	64
EPHEMEROPTERA						13	1838	
Attenella margarita	5	5	0	1	11	0	28	26
Baetis insignificans	70	21	104	54	249	4	623	345
Baetis tricaudatus	30	137	161	122	450	8	1125	573
Psuedocloeon sp.	2	0	0	0	2	0	5	10
Rhithrogena sp.	3	2	3	2	10	0	25	6
Seratella tibialis	3	0	1	0	4	0	10	14
Tricorythodes minutus	5	1	0	3	9	0	23	22
COLEOPTERA						2	243	
Optioservus								
quadrimaculatus	2	2	7	0	11	0	28	30
divergins/pecosensis	9	4	17	15	45	1	113	59
Zaitzevia parva	6	15	6	14	41	1	103	49
PLECOPTERA						2	255	
Doroneuria theodora	7	9	1	2	19	0	48	39
Isogenoides sp.	10	21	6	0	37	1	93	88
Pteronarcella badia	4	22	6	3	35	1	88	89
Pteronarcys californica	0	3	0	0	3	0	8	15
Skwala sp.	3	1	2	2	8	0	20	8

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 22 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
TRICHOPTERA						65	9083	
Arctopsyche grandis	1	1	2	9	13	0	33	39
Brachycentrus occidentalis	4	7	8	6	25	0	63	17
Ceraclea sp. 1	0	0	1	0	1	0	3	5
Cheumatopsyche spp.	112	48	88	50	298	5	745	310
Glossosoma sp.	1	1	0	0	2	0	5	6
Hydropsyche								
(Ceratopsyche) sp.1	31	26	53	78	188	3	470	238
(Hydropsyche) sp.1	261	930	737	1174	3102	56	7755	3868
Hydroptila sp.	0	0	2	0	2	0	5	10
Oecetis sp.	2	0	0	0	2	0	5	10
LEPIDOPTERA								
Petrophila sp.	1	0	3	0	4	0	10	14
HEMIPTERA								
corrixid nymph	0	1	0	0	1	0	3	5
TOTAL NUMBER	640	1718	1373	1853	5584	100	13960	5430
TOTAL TAXA	32	28	32	25	42		29	3
S.W. DIVERSITY	3.08	2.35	2.54	2.10	2.52		2.52	0.41
EQUITABILITY	0.37	0.25	0.25	0.23	0.19		0.28	0.06
BIOTIC INDEX					2.93			
BIOT. COND. INDEX					54			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 23 (CFR @ Alberton)
DATE: August 13, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN #/m2	STAND DEV
	A	B	C	D				
DIPTERA						6	558	
unassoc. chiron pupa	6	9	11	11	37	1	93	24
Atherix pachypus	0	1	1	1	3	0	8	5
Cardiocladius spp.	3	4	6	15	28	1	70	55
Cricotopus								
(C.) bicinctus gp	1	2	1	0	4	0	10	8
(C.) tremelus gp	5	6	3	5	19	0	48	13
(C.) trifascia gp	3	1	1	0	5	0	13	13
/Orthocladius	1	2	1	1	5	0	13	5
Micropsectra sp.	1	1	0	7	9	0	23	32
Microtendipes pedellus gp	2	3	2	2	9	0	23	5
Monodiamesa sp.	1	0	0	0	1	0	3	5
Nanocladius parvulus gp	0	0	1	0	1	0	3	5
Orthocladius sp. (Euorthocladius) sp	1	0	0	0	1	0	3	5
Potthastia gaedii gp	1	0	0	0	1	0	3	5
Polypedilum sp.	15	24	18	27	84	2	210	55
Rheotanytarsus sp.	2	7	0	0	9	0	23	33
Palpomyia complex	0	0	1	0	1	0	3	5
Thienemannimyia gp	0	1	1	1	3	0	8	5
Tvetenia sp.	1	0	0	2	3	0	8	10
EPHEMEROPTERA						13	1288	
Attenella margarita	1	6	1	2	10	0	25	24
Baetis bicaudatus	0	0	1	0	1	0	3	5
Baetis insignificans	109	84	80	76	349	9	873	149
Baetis tricaudatus	43	13	17	16	89	2	223	139
Drunella grandis	0	1	3	3	7	0	18	15
Heptagenia sp.	3	7	5	2	17	0	43	22
Psuedocloeon sp.	0	2	3	1	6	0	15	13
Seratella tibialis	1	0	0	1	2	0	5	6
Tricorythodes minutus	5	10	10	9	34	1	85	24
COLEOPTERA						1	115	
Optioservus								
quadrimaculatus	8	5	3	6	22	1	55	21
divergins/pecosensi	7	4	1	5	17	0	43	25
Zaitzevia parva	2	3	1	1	7	0	18	10

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 23 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
PLECOPTERA						2	205	
Doroneuria theodora	1	1	1	0	3	0	8	5
Hesperoperla pacifica	0	0	2	2	4	0	10	12
Isogenoides sp.	14	24	11	7	56	1	140	73
Pteronarcella badia	5	2	4	3	14	0	35	13
Pteronarcys californica	0	0	0	1	1	0	3	5
Skwala sp.	2	0	1	1	4	0	10	8
TRICHOPTERA						75	7455	
Arctopsyche grandis	1	0	17	2	20	1	50	80
Brachycentrus occidentalis	0	3	6	1	10	0	25	26
Ceraclea sp. 1	5	2	1	4	12	0	30	18
Ceraclea sp. 2	0	0	0	1	1	0	3	5
Cheumatopsyche spp.	236	188	297	342	1063	27	2658	676
Hydropsyche (Ceratopsyche) sp.1	144	89	306	231	770	19	1925	956
(Hydropsyche) sp.1	154	122	384	299	959	24	2398	1232
Hydroptila sp.	1	5	0	0	6	0	15	24
Oecetis sp.	2	1	0	3	6	0	15	13
Psychomyia flavida	5	12	19	23	59	1	148	79
Zumatrichia sp.	10	16	10	40	76	2	190	143
LEPIDOPTERA								
Petrophila sp.	18	27	29	35	109	3	273	70
ODONATA								
Ophiogomphus sp.	0	0	0	1	1	0	3	5
TOTAL NUMBER	820	688	1260	1190	3958	100	9895	2787
TOTAL TAXA	36	34	36	37	49		36	1
S.W. DIVERSITY	3.12	3.44	2.77	2.98	3.10		3.08	0.28
EQUITABILITY	0.34	0.46	0.26	0.30	0.25		0.34	0.09
BIOTIC INDEX					2.87			
BIOT. COND. INDEX					53			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 24 (CFR @ Superior)
DATE: August 13, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						16	833	
unassoc. chiron pupa	15	10	17	3	45	2	113	62
Antocha sp.	1	2	2	2	7	0	18	5
Cladotanytarsus vanderwulpi gp	0	3	2	0	5	0	13	15
Cricotopus								
(C.) bicinctus gp	1	2	2	0	5	0	13	10
(C.) tremelus gp	0	1	4	2	7	0	18	17
/Orthocladius	1	1	2	0	4	0	10	8
Eukiefferiella coerulescens gp	1	0	0	0	1	0	3	5
Hexatoma sp.	0	1	0	0	1	0	3	5
Micropsectra sp.	8	3	2	0	13	1	33	34
Microtendipes pedellus gp	7	4	6	4	21	1	53	15
Orthocladius sp.								
(Euorthocladius) sp	0	0	0	1	1	0	3	5
(Orthocladius) sp.	0	0	0	1	1	0	3	5
Pagastia sp.	1	1	1	2	5	0	13	5
Polypedilum sp.	29	24	30	27	110	5	275	26
Rheotanytarsus sp.	29	37	18	12	96	4	240	112
Simulium sp.	0	0	0	1	1	0	3	5
Thienemannimyia sp.	5	2	0	1	8	0	20	22
Tvetenia sp.	0	1	1	0	2	0	5	6
EPHEMEROPTERA						11	608	
Attenella margarita	6	1	4	1	12	1	30	24
Ameletus sp.	1	0	0	0	1	0	3	5
Baetis insignificans	51	24	19	21	115	5	288	150
Baetis tricaudatus	35	13	18	13	79	4	198	104
Drunella grandis	1	3	3	2	9	0	23	10
Epemerella inermis/infrequens	1	0	0	1	2	0	5	6
Seratella tibialis	1	3	2	1	7	0	18	10
Tricorythodes minutus	10	3	5	0	18	1	45	42
COLEOPTERA						1	63	
Zaitzevia parva	2	1	0	2	5	0	13	10
Optioservus								
quadrimaculatus	1	3	4	3	11	1	28	13
divergins/pecosensis	4	0	1	4	9	0	23	21

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 24 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
PLECOPTERA						1	60	
Claassinia sabulosa	0	0	1	0	1	0	3	5
Doroneuria theodora	4	1	2	1	8	0	20	14
Hesperoperla pacifica	0	1	0	0	1	0	3	5
Isogenoides sp.	6	3	3	2	14	1	35	17
TRICHOPTERA						68	3628	
Arctopsyche grandis	3	9	2	4	18	1	45	31
Brachycentrus occidentalis	2	1	1	4	8	0	20	14
Ceraclea sp. 1	0	0	2	0	2	0	5	10
Cheumatopsyche spp.	152	145	118	65	480	22	1200	395
Hydropsyche								
(Ceratopsyche) spp.	51	72	24	35	182	8	455	209
(Hydropsyche) spp.	97	117	100	90	404	19	1010	115
Hydroptila sp.	1	2	7	2	12	1	30	27
Luecotrichia sp.	0	0	2	0	2	0	5	10
Oecetis sp.	3	1	0	0	4	0	10	14
Psychomyia flavida	114	37	91	86	328	15	820	324
Zumatrichia sp.	3	2	2	4	11	1	28	10
LEPIDOPTERA								
Petrophila sp.	22	17	11	13	63	3	158	49
OLIGOCHAETA								
Lumbricidae	6	1	0	0	7	0	18	29
TOTAL NUMBER	675	552	509	410	2146	100	5365	1098
TOTAL TAXA	34	35	33	30	46		33	2
S.W. DIVERSITY	3.57	3.38	3.46	3.44	3.56		3.46	0.08
EQUITABILITY	0.50	0.43	0.48	0.52	0.37		0.48	0.04
BIOTIC INDEX					2.73			
BIOT. COND. INDEX					52			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION:	25 (CFR above Flathead River)
DATE:	August 13, 1986
SAMPLE TYPE:	modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
DIPTERA						21	518	
unassoc. chiron pupa	2	3	6	6	17	2	43	21
Antocha sp.	0	1	0	0	1	0	3	5
Cladotanytarsus vanderwulpi gp	0	0	1	0	1	0	3	5
Cricotopus								
(C.) bicinctus gp	6	3	2	11	22	2	55	40
(C.) tremelus gp	0	1	0	0	1	0	3	5
/Orthocladius	1	0	1	0	2	0	5	6
Eukiefferiella coerulescens gp	1	0	0	0	1	0	3	5
Micropsectra sp.	3	1	0	6	10	1	25	26
Microtendipes pedellus gp	12	1	15	22	50	5	125	87
Orthocladius sp. (Orthocladius) sp.	0	1	0	1	2	0	5	6
Phaenospectra sp.	0	0	0	3	3	0	8	15
Polypedilum sp.	6	4	5	8	23	2	58	17
Rheotanytarsus sp.	26	7	2	24	59	6	148	120
Tanytarsus sp.	2	0	1	0	3	0	8	10
Thienenannimyia gp	0	0	2	6	8	1	20	28
Tvetenia sp.	3	0	0	1	4	0	10	14
EPHEMEROPTERA						6	150	
Attenella margarita	0	1	0	0	1	0	3	5
Ameletus sp.	1	1	0	0	2	0	5	6
Baetis insignificans	8	15	4	7	34	3	85	47
Baetis tricaudatus	0	1	0	0	1	0	3	5
Drunella grandis	0	0	0	1	1	0	3	5
Epeorus albertae	0	2	0	0	2	0	5	10
Ephemerella inermis/infrequens	0	0	1	1	2	0	5	6
Heptagenia solitaria	1	0	0	0	1	0	3	5
Paraleptophlebia bicornuta	1	1	1	5	8	1	20	20
Seratella tibialis	2	0	0	0	2	0	5	10
Tricorythodes minutus	3	1	0	2	6	1	15	13
COLEOPTERA						1	13	
Zaitzevia parva	1	1	0	1	3	0	8	5
Optioservus divergins/pecosensis	1	0	1	0	2	0	5	6

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 25 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN #/m2	STAND DEV
PLECOPTERA						3	70	
Isogenoides sp.	4	6	11	7	28	3	70	29
TRICHOPTERA						65	1618	
Arctopsyche grandis	2	0	0	0	2	0	5	10
Brachycentrus occidentalis	2	0	0	0	2	0	5	10
Ceraclea sp. 1	2	2	6	5	15	2	38	21
Cheumatopsyche spp.	105	39	57	127	328	33	820	409
Hydropsyche								
(Ceratopsyche) sp.1	43	1	13	45	102	10	255	219
(Hydropsyche) sp.1	15	3	5	12	35	4	88	57
Hydroptila sp.	0	1	0	2	3	0	8	10
Luecotrichia sp.	3	1	3	1	8	1	20	12
Oecetis sp.	0	1	0	0	1	0	3	5
Psychomyia flavida	36	14	34	42	126	13	315	122
Zumatrichia sp.	13	0	2	10	25	3	63	62
LEPIDOPTERA								
Petrophila sp.	16	1	14	16	47	5	118	72
OLIGOCHAETA								
Limnodrilus hoffmeisteri	1	0	0	1	2	0	5	6
PORIFERA (present)								
TOTAL NUMBER	322	114	187	373	996	100	2490	1194
TOTAL TAXA	29	26	21	26	43		26	3
S.W. DIVERSITY	3.47	3.42	3.28	3.41	3.58		3.40	0.08
EQUITABILITY	0.54	0.59	0.66	0.59	0.40		0.60	0.05
BIOTIC INDEX					2.72			
BIOT. CON. INDEX					52			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 26 (Flathead River near mouth)
DATE: August 14, 1986
SAMPLE TYPE: traveling kick

TAXON	SAMPLE # A	%RA
DIPTERA		9
unassoc. chiron pupa	1	1
Microtendipes pedellus gp	3	2
Nanocladius parvulus gp	2	2
Paracladopelma sp.	1	1
Polypedilum sp.	1	1
Potthastia longimana gp	1	1
Rheotanytarsus sp.	2	2
EPHEMEROPTERA		52
Baetis insignificans	3	2
Baetis tricaudatus	3	2
Heptagenia soltari	17	14
Nixe sp.	2	2
Stenonema sp.	38	31
COLEOPTERA		7
Dubiraphia sp.	4	3
Zaitzevia parva	4	3
LEPIDOPTERA		2
Petrophila sp.	2	2
TRICHOPTERA		21
Ceraclea sp. 1	7	6
Cheumatopsyche spp.	17	14
Polycentropus sp.	1	1
ODONATA		
Ophiogomphus sp.	1	1
AMPHIPODA		
Hyalella azteca	3	2
MOLLUSCA		
Gyraulus sp.	8	7
TOTAL NUMBER	121	100
TOTAL TAXA	20	
S.W. DIVERSITY	3.36	
EQUITABILITY	0.73	
BIOTIC INDEX	2.31	
BIOT. CON. INDEX	72	

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 27 (CFR above Thompson Falls Reservoir)
DATE: August 14, 1986
SAMPLE TYPE: traveling kick

	SAMPLE #				SUM	%RA	MEAN	STAND DEV
TAXON	A	B	C	D				
DIPTERA						28	206	
unassoc. chiron pupa	10	15	34	10	69	2	17	11
Cladotanytarsus vanderwulpi gp	77	55	161	87	380	13	95	46
Cricotopus (C.) bicinctus gp	9	15	7	26	57	2	14	9
/Orthocladius	0	1	3	3	7	0	2	2
Dicrotendipes sp.	1	0	1	0	2	0	1	1
Micropsectra sp.	12	4	7	14	37	1	9	5
Microtendipes pedellus gp	4	7	24	19	54	2	14	10
Orthocladius sp. (Orthocladius) sp.	0	1	1	3	5	0	1	1
Polypedilum sp.	17	12	13	18	60	2	15	3
Pseudochironomus sp.	0	1	4	7	12	0	3	3
Rheotanytarsus sp.	4	8	17	16	45	2	11	6
Simulium sp.	1	5	2	0	8	0	2	2
Synorthocladius sp.	2	2	0	6	10	0	3	3
Tanytarsus sp.	1	1	2	2	6	0	2	1
Thienemannimyia gp	7	3	9	10	29	1	7	3
Tvetenia sp.	3	10	8	22	43	1	11	8
EPHEMEROPTERA						14	101	
Attenella margarita	0	0	2	5	7	0	2	2
Baetis insignificans	2	12	5	9	28	1	7	4
Baetis tricaudatus	2	1	1	4	8	0	2	1
Drunella grandis	1	1	0	0	2	0	1	1
Epeorus albertae	0	1	0	1	2	0	1	1
Heptagenia soltaria	4	1	3	3	11	0	3	1
Stenonema sp.	77	72	43	107	299	10	75	26
Tricorythodes minutus	5	1	4	17	27	1	7	7
Timpango hecuba	6	3	6	3	18	1	5	2
COLEOPTERA						5	33	
Oreodytes sp.2	0	1	0	3	4	0	1	1
Optioservus quadrimaculatus	1	0	0	0	1	0	0	1
divergins/pecosensi	2	2	1	1	6	0	2	1
Zaitzevia parva	31	36	20	34	121	4	30	7
PLECOPTERA						0	3	
Doroneuria theodora	2	3	2	1	8	0	2	1
Isogenoides sp.	0	1	0	2	3	0	1	1

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 27 (Concluded)

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN	STAND DEV
TRICHOPTERA						38	274	
Ceraclea sp. 1	33	11	16	18	78	3	20	9
Brachycentrus occidentalis	0	1	0	0	1	0	0	1
Cheumatopsyche spp.	117	157	266	249	789	27	197	72
Glossosomatidae	0	1	0	0	1	0	0	1
Hydropsyche								
(Ceratopsyche) sp.1	27	25	71	29	152	5	38	22
(Hydropsyche) sp.1	9	12	25	11	57	2	14	7
Psychomyia flavida	4	1	5	9	19	1	5	3
LEPIDOPTERA								
Petrophila sp.	6	7	2	10	25	1	6	3
ODONATA								
Ophiogomphus sp.	6	7	4	4	21	1	5	2
MOLLUSCA						13	95	
Ferrissia sp.	7	6	10	0	23	1	6	4
Gyraulus sp.	0	0	1	6	7	0	2	3
Helisoma sp.	1	1	0	0	2	0	1	1
Lymnaea sp.	49	48	122	104	323	11	81	38
Physa sp.	4	1	3	1	9	0	2	2
Sphaerium sp.	1	12	0	2	15	1	4	6
HYDRACARINA	1	2	0	1	4	0	1	1
OLIGOCHAETA						0	4	
Lumbricidae	1	0	8	0	9	0	2	4
Lumbriculidae	1	4	0	0	5	0	1	2
TOTAL NUMBER	548	571	913	877	2909	100	727	194
TOTAL TAXA	38	43	36	38	49		39	3
S.W. DIVERSITY	3.84	3.86	3.44	3.78	3.81		3.73	0.19
EVENESS	0.73	0.71	0.67	0.72	0.68		0.71	0.03
EQUITABILITY	0.55	0.49	0.43	0.52	0.42		0.50	0.05
BIOTIC INDEX					2.66			
BIOT. COND. INDEX					53			

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 28 (CFR below Thompson Falls Dam)
DATE: August 14, 1986
SAMPLE TYPE: traveling kick

TAXON	SAMPLE # A	%RA
DIPTERA		64
unassoc. chiron pupa	1	2
Dicrotendipes sp.	19	33
Cricotopus (C.) or Orthocladius (O.)	7	12
Microtendipes pedellus gp	1	2
Parachironomus frequens gp	2	3
Rheotanytarsus sp.	5	9
Tanytarsus sp.	1	2
Thienemannimyia gp	1	2
EPHEMEROPTERA		12
Ameletus sp.	3	5
Heptagenia soltaria	1	2
Stenonema sp.	2	3
Tricorythodes minutus	1	2
TRICHOPTERA		14
Ceraclea sp. 1	2	3
Cheumatopsyche spp.	5	9
Hydropsyche (Ceratopsyche) sp.1	1	2
OLIGOCHAETA		
Lumbricidae	6	10
TOTAL NUMBER	58	100
TOTAL TAXA	15	
S.W. DIVERSITY	3.20	
EQUITABILITY	0.87	
BIOTIC INDEX	3.26	
BIOT. COND. INDEX	51	

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 30 (CFR below Cabinet Gorge Dam)
DATE: August 14, 1986
SAMPLE TYPE: traveling kick

TAXON	SAMPLE # A	%RA
DIPTERA		30
unassoc. chiron pupa	11	6
Cladotanytarsus van	8	4
Cryptochironomus sp.	1	1
Cricotopus		
(C.) tremelus gp	2	1
/Orthocladius	9	5
Dicrotendipes sp.	3	2
Microtendipes		
pedellus gp	9	5
Polypedilum sp.	1	1
Rheotanytarsus sp.	1	1
Synorthocladius sp.	4	2
Tanytarsus sp.	2	1
Thienemannimyia gp	5	3
EPHEMEROPTERA		57
Ameletus sp.	11	6
Paraleptophlebia		
bicornuta	74	40
Stenonema sp.	4	2
Tricorythodes		
minutus	15	8
TRICHOPTERA		10
Ceraclea sp. 1	1	1
Cheumatopsyche spp.	5	3
Hydropsyche		
(Ceratopsyche) sp.1	2	1
Hydroptila sp.	8	4
Mystacides sp.	1	1
Psychomyia flavida	1	1

APPENDIX D

CLARK FORK RIVER MACROINVERTEBRATE STUDY
BIOMASS DATA AND SUMMARY STATISTICS

CLARK FORK RIVER MACROINVERTEBRATE DATA

STATION: 30 (Concluded)

TAXON	SAMPLE # A	%RA
MOLLUSCA		2
Helisoma sp.	1	1
Lymnaea sp.	1	1
Physa sp.	1	1
OLIGOCHAETA		2
Lumbriculidae	2	1
Ophiodonais serpintina	1	1
CLADOCERA (present)		
TOTAL NUMBER	184	100
TOTAL TAXA	26	
S.W. DIVERSITY	3.31	
EVENESS	0.68	
EQUITABILITY	0.54	
BIOTIC INDEX	1.96	
BIOT. COND. INDEX	77	

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WEIGHT)

STATION: 1 (Silverbow Ck below Colorado tailings)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
DIPTERA	0.59	0.69	1.18	2.70	5.16	100	12.9	9.7
EPHEMEROPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TRICHOPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	0.6	0.7	1.2	2.7	5.2	100	12.9	9.7

STATION: 2 (Silverbow Ck @ Ramsey)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.02	0.01	0.00	0.04	16	0.1	0.1
DIPTERA	0.04	0.05	0.05	0.04	0.18	72	0.5	0.1
EPHEMEROPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TRICHOPTERA	0.01	0.00	0.02	0.00	0.03	12	0.1	0.1
TOTAL WEIGHT	0.1	0.1	0.1	0.0	0.3	100	0.6	0.2

STATION: 3 (Silverbow Ck @ frontage road)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.04	0.04	0.02	0.01	0.11	19	0.3	0.2
DIPTERA	0.01	0.03	0.04	0.01	0.09	16	0.2	0.2
MEGALOPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TRICHOPTERA	0.02	0.19	0.10	0.06	0.37	65	0.9	0.7
AMPHIPODA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	0.1	0.3	0.2	0.1	0.6	100	1.4	0.9

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 4 (ACM pond #2 discharge - SBC)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			gm/m2	DEV
COLEOPTERA	0.16	0.03	0.09	0.05	0.33	2	0.8	0.6
DIPTERA	2.81	0.99	0.35	0.27	4.42	23	11.1	11.8
TRICHOPTERA	3.68	1.04	1.51	1.84	8.07	42	20.2	11.6
AMPHIPODA	1.80	0.96	1.24	1.71	5.71	30	14.3	4.0
HIRUDINEA	0.01	0.05	0.24	0.02	0.32	2	0.8	1.1
MOLLUSCA	0.01	0.00	0.30	0.09	0.40	2	1.0	1.4
TOTAL WEIGHT	8.5	3.1	3.7	4.0	19.3	100	48.1	24.7

STATION: 5 (Mill-Willow Cks bypass)
DATE: August 11, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			gm/m2	DEV
COLEOPTERA	0.00	0.00	0.01	0.01	0.02	1	0.1	0.1
DIPTERA	0.01	0.14	0.16	0.31	0.62	20	1.6	1.2
EPHEMEROPTERA	0.05	0.14	0.10	0.13	0.42	14	1.1	0.4
PLECOPTERA	0.05	0.00	0.02	0.10	0.17	6	0.4	0.4
TRICHOPTERA	0.21	0.28	0.34	1.02	1.85	60	4.6	3.8
AMPHIPODA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
MOLLUSCA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	0.3	0.6	0.6	1.6	3.1	100	7.7	5.5

STATION: 6
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE #				SUM	%RA	MEAN	STAND
	A	B	C	D			gm/m2	DEV
COLEOPTERA	0.02	0.02	0.01	0.02	0.07	3	0.2	0.1
DIPTERA	0.06	0.02	0.00	0.07	0.15	6	0.4	0.3
EPHEMEROPTERA	0.05	0.04	0.02	0.01	0.12	4	0.3	0.2
PLECOPTERA	0.41	0.41	0.13	1.22	2.17	80	5.4	4.7
TRICHOPTERA	0.06	0.08	0.01	0.06	0.21	8	0.5	0.3
TOTAL WEIGHT	0.6	0.6	0.2	1.4	2.7	100	6.8	5.1

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 7(CFR below Warm Springs Creek)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.18	0.04	0.10	0.04	0.36	4	0.9	0.7
DIPTERA	0.15	0.05	0.23	0.17	0.60	6	1.5	0.7
EPHEMEROPTERA	0.18	0.03	0.04	0.09	0.34	4	0.9	0.7
MEGALOPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
PLECOPTERA	1.38	0.18	0.50	0.89	2.95	31	7.4	5.2
TRICHOPTERA	2.50	0.81	0.88	0.95	5.14	55	12.9	8.1
AMPHIPODA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
MOLLUSCA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	4.4	1.1	1.8	2.1	9.4	100	23.5	14.3

STATION: 8 (CFR near Dempsey)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.03	0.11	0.07	0.14	0.35	6	0.9	0.5
DIPTERA	0.08	0.12	0.09	0.20	0.49	9	1.2	0.5
EPHEMEROPTERA	0.01	0.03	0.18	0.02	0.24	4	0.6	0.8
MEGALOPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
PLECOPTERA	0.21	0.39	0.51	0.44	1.55	27	3.9	1.3
TRICHOPTERA	0.17	0.99	0.88	0.98	3.02	53	7.6	3.9
AMPHIPODA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	0.5	1.6	1.7	1.8	5.7	100	14.1	6.1

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 9 (CFR @ Deer Lodge)
DATE: August 21,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.02	0.01	0.04	0.10	0.17	1	0.4	0.4
DIPTERA	0.24	0.37	0.18	0.20	0.99	8	2.5	0.9
EPHEMEROPTERA	0.15	0.10	0.22	0.09	0.56	5	1.4	0.6
ODONATA	0.00	0.06	0.00	0.00	0.06	0	0.2	0.3
PLECOPTERA	0.13	0.22	0.54	0.30	1.19	10	3.0	1.8
TRICHOPTERA	1.57	1.75	3.87	1.91	9.10	75	22.8	10.7
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	2.1	2.5	4.9	2.6	12.1	100	30.2	12.4

STATION: 10 (CFR above Little Blackfoot R.)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.05	0.03	0.01	0.10	0	0.3	0.2
DIPTERA	0.17	0.44	1.42	1.59	3.62	18	9.1	7.0
EPHEMEROPTERA	0.49	0.21	0.46	0.40	1.56	8	3.9	1.3
ODONATA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
PLECOPTERA	0.49	1.24	0.78	0.30	2.81	14	7.0	4.1
TRICHOPTERA	2.28	3.00	2.44	4.72	12.44	61	31.1	11.2
TOTAL WEIGHT	3.4	4.9	5.1	7.0	20.5	100	51.3	14.7

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 11 (CFR @ Gold Creek)
DATE: August 21, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.00	0.01	0.02	0.04	1	0.1	0.1
DIPTERA	0.56	0.14	0.16	0.44	1.30	17	3.3	2.1
EPHEMEROPTERA	0.10	0.20	0.12	0.08	0.50	7	1.3	0.5
PLECOPTERA	0.16	0.08	0.28	1.40	1.92	26	4.8	6.2
TRICHOPTERA	2.08	0.22	0.26	1.19	3.75	50	9.4	8.8
TOTAL WEIGHT	2.9	0.6	0.8	3.1	7.5	100	18.8	13.2

STATION: 12 (CFR @ Bonita)
DATE: August 21, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.03	0.02	0.01	0.01	0.07	1	0.2	0.1
DIPTERA	0.94	0.79	0.98	0.52	3.23	31	8.1	2.1
EPHEMEROPTERA	0.19	0.13	0.18	0.13	0.63	6	1.6	0.3
PLECOPTERA	0.55	0.50	0.36	0.13	1.54	15	3.9	1.9
TRICHOPTERA	1.61	0.64	0.56	2.24	5.05	48	12.6	8.1
TOTAL WEIGHT	3.3	2.1	2.1	3.0	10.5	100	26.3	6.4

STATION: 13 (CFR @ Turah)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.02	0.03	0.05	0.07	0.17	1	0.4	0.2
DIPTERA	0.69	1.45	0.30	0.25	2.69	10	6.7	5.5
EPHEMEROPTERA	0.15	0.16	0.18	0.24	0.73	3	1.8	0.4
PLECOPTERA	0.99	0.12	7.32	4.58	13.01	50	32.5	33.3
TRICHOPTERA	3.35	2.08	3.24	0.78	9.45	36	23.6	12.0
TOTAL WEIGHT	5.2	3.8	11.1	5.9	26.1	100	65.1	31.7

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 14 (Blackfoot River near mouth)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.00	0.01	0.00	0.02	0	0.1	0.1
DIPTERA	0.08	0.21	0.07	0.04	0.40	9	1.0	0.8
EPHEMEROPTERA	0.01	0.02	0.03	0.03	0.09	2	0.2	0.1
PLECOPTERA	1.49	0.10	0.31	0.64	2.54	60	6.4	6.1
TRICHOPTERA	0.10	0.05	0.17	0.27	0.59	14	1.5	1.0
MOLLUSCA	0.58	0.00	0.01	0.00	0.59	14	1.5	2.9
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	2.3	0.4	0.6	1.0	4.2	100	10.6	8.5

STATION: 15 (CFR below Milltown Dam)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.03	0.04	0.05	0.01	0.13	1	0.3	0.2
DIPTERA	0.91	0.35	0.02	0.10	1.38	9	3.5	4.0
EPHEMEROPTERA	0.09	0.13	0.09	0.05	0.36	2	0.9	0.3
LEPIDOPTERA	0.02	0.00	0.02	0.02	0.06	0	0.2	0.1
PLECOPTERA	3.46	0.62	0.24	0.35	4.67	32	11.7	15.4
TRICHOPTERA	2.51	1.83	2.14	1.49	7.97	55	19.9	4.4
TOTAL WEIGHT	7.0	3.0	2.6	2.0	14.6	100	36.4	22.9

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 16 (CFR above Missoula WWTP)
DATE: August 12, 1986
SAMPLE TYPE: modified hess

	SAMPLE #				SUM	%RA	MEAN	STAND
TAXON	A	B	C	D			gm/m2	DEV
COLEOPTERA	0.00	0.00	0.01	0.03	0.04	0	0.1	0.1
DIPTERA	0.18	0.03	0.03	0.02	0.26	2	0.7	0.8
EPHEMEROPTERA	0.03	0.02	0.03	0.07	0.15	1	0.4	0.2
LEPIDOPTERA	0.00	0.04	0.00	0.01	0.05	0	0.1	0.2
ODONATA	0.00	0.00	0.00	0.12	0.12	1	0.3	0.6
PLECOPTERA	1.69	0.74	0.40	0.81	3.64	27	9.1	5.5
TRICHOPTERA	2.30	1.19	2.38	3.15	9.02	68	22.6	8.1
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	4.2	2.0	2.9	4.2	13.3	100	33.2	10.8

STATION: 18 (CFR @ Shuffield's)
DATE: August 11,1986
SAMPLE TYPE: modified hess

	SAMPLE #				SUM	%RA	MEAN	STAND
TAXON	A	B	C	D			gm/m2	DEV
COLEOPTERA	0.00	0.01	0.00	0.00	0.01	0	0.0	0.1
DIPTERA	0.01	0.03	0.02	0.06	0.12	1	0.3	0.2
EPHEMEROPTERA	0.05	0.06	0.10	0.03	0.24	2	0.6	0.3
LEPIDOPTERA	0.00	0.01	0.03	0.02	0.06	0	0.2	0.1
PLECOPTERA	0.28	2.14	0.08	0.28	2.78	21	7.0	9.7
TRICHOPTERA	1.30	3.04	3.69	1.83	9.86	75	24.7	10.9
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	1.6	5.3	3.9	2.2	13.1	100	32.7	16.6

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 19 (Bitterroot River near mouth)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.03	0.10	0.50	0.17	0.80	7	2.0	2.1
DIPTERA	0.06	0.14	0.10	0.25	0.55	5	1.4	0.8
EPHEMEROPTERA	0.03	0.06	0.08	0.25	0.42	4	1.1	1.0
LEPIDOPTERA	0.00	0.08	0.02	0.01	0.11	1	0.3	0.4
PLECOPTERA	0.02	0.68	0.09	0.50	1.29	11	3.2	3.2
TRICHOPTERA	1.35	2.01	2.32	2.48	8.16	71	20.4	5.0
OLIGOCHAETA	0.04	0.06	0.00	0.03	0.13	1	0.3	0.3
TOTAL WEIGHT	1.5	3.1	3.1	3.7	11.5	100	28.7	9.3

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 20 (CFR @ Harper Bridge)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.00	0.01	0.00	0.01	0.02	0	0.1	0.1
DIPTERA	0.14	0.05	0.16	0.58	0.93	8	2.3	2.4
EPHEMEROPTERA	0.05	0.19	0.20	0.21	0.65	6	1.6	0.8
LEPIDOPTERA	0.00	0.00	0.01	0.00	0.01	0	0.0	0.1
PLECOPTERA	0.07	0.48	0.07	0.42	1.04	9	2.6	2.2
TRICHOPTERA	1.97	0.97	2.77	3.30	9.01	77	22.5	10.1
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	2.2	1.7	3.2	4.5	11.7	100	29.2	12.4

STATION: 22 (CFR @ Huson)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.04	0.02	0.03	0.02	0.11	1	0.3	0.1
DIPTERA	0.07	0.58	0.35	0.49	1.49	10	3.7	2.2
EPHEMEROPTERA	0.11	0.20	0.28	0.21	0.80	5	2.0	0.7
LEPIDOPTERA	0.01	0.00	0.01	0.00	0.02	0	0.1	0.1
PLECOPTERA	0.92	1.33	0.03	0.68	2.96	19	7.4	5.4
TRICHOPTERA	1.24	2.51	2.04	4.17	9.96	65	24.9	12.4
HEMIPTERA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	2.4	4.6	2.7	5.6	15.3	100	38.4	15.2

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WT)

STATION: 23 (CFR near Alberton)
DATE: August 11,1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.01	0.00	0.01	0.03	0	0.1	0.1
DIPTERA	0.02	0.04	0.03	0.05	0.14	1	0.4	0.1
EPHEMEROPTERA	0.24	0.20	0.22	0.19	0.85	5	2.1	0.2
LEPIDOPTERA	0.04	0.08	0.07	0.12	0.31	2	0.8	0.3
ODONATA	0.00	0.00	0.00	0.01	0.01	0	0.0	0.1
PLECOPTERA	0.29	0.27	0.21	0.30	1.07	7	2.7	0.4
TRICHOPTERA	2.81	1.94	5.17	3.53	13.45	85	33.6	13.7
TOTAL WEIGHT	3.4	2.5	5.7	4.2	15.9	100	39.7	13.4

STATION: 24 (CFR @ Superior)
DATE: August 13, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.00	0.00	0.01	0.02	0	0.1	0.1
DIPTERA	0.06	0.09	0.06	0.04	0.25	4	0.6	0.2
EPHEMEROPTERA	0.10	0.07	0.06	0.03	0.26	4	0.7	0.3
LEPIDOPTERA	0.04	0.04	0.02	0.04	0.14	2	0.4	0.1
PLECOPTERA	0.32	0.04	0.37	0.09	0.82	12	2.1	1.6
TRICHOPTERA	1.40	1.65	1.04	1.00	5.09	75	12.7	3.1
OLIGOCHAETA	0.21	0.02	0.00	0.00	0.23	3	0.6	1.0
TOTAL WEIGHT	2.1	1.9	1.6	1.2	6.8	100	17.0	4.1

CLARK FORK RIVER MACROINVERTEBRATE DATA
BIOMASS (GRAMS WET WEIGHT)

STATION: 25 (CFR above Flathead R.)
DATE: August 13, 1986
SAMPLE TYPE: modified hess

TAXON	SAMPLE # A	B	C	D	SUM	%RA	MEAN gm/m2	STAND DEV
COLEOPTERA	0.01	0.00	0.00	0.00	0.01	0	0.0	0.1
DIPTERA	0.03	0.01	0.01	0.07	0.12	4	0.3	0.3
EPHEMEROPTERA	0.03	0.05	0.01	0.05	0.14	4	0.4	0.2
LEPIDOPTERA	0.07	0.00	0.05	0.07	0.19	6	0.5	0.3
PLECOPTERA	0.03	0.09	0.12	0.03	0.27	8	0.7	0.5
TRICHOPTERA	0.93	0.20	0.44	1.03	2.60	78	6.5	4.0
OLIGOCHAETA	0.00	0.00	0.00	0.00	0.00	0	0.0	0.0
TOTAL WEIGHT	1.1	0.4	0.6	1.3	3.3	100	8.3	4.2

APPENDIX E

Percentage community similarity coefficients (PCS x 100) for 23 locations on the Clark Fork River and selected tributaries during August, 1986 (four Hess samples pooled at each station).

	STATION																					
STATION	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20	22	23	24	25
1	7	4	21	25	1	4	1	4	21	21	1	6	1	4	7	1	6	14	14	2	1	1
2		25	3	8	7	5	7	4	2	3	1	6	5	10	6	2	9	3	3	4	3	1
3			5	10	11	8	9	4	4	5	2	10	6	14	10	5	9	7	7	7	6	5
4				34	7	17	6	9	27	25	4	10	7	14	25	24	24	22	24	28	27	27
5					41	55	50	42	56	62	41	45	21	33	44	39	54	59	54	47	43	26
6						48	44	26	21	30	28	29	25	26	25	22	31	28	25	20	22	12
7							75	60	59	43	54	45	22	32	38	33	50	66	66	43	40	20
8								60	56	40	61	41	22	25	32	32	49	60	59	41	34	16
9									71	42	77	33	17	12	19	19	36	60	71	29	26	6
10										59	69	36	14	16	24	22	36	68	81	31	29	9
11											44	50	23	23	30	29	41	54	53	35	35	16
12												36	15	16	21	25	37	59	72	31	29	12
13													29	55	37	38	59	45	43	43	44	22
14														27	24	23	32	27	21	26	27	18
15															59	58	49	28	27	45	38	31
16																75	50	39	37	56	45	35
18																	52	35	31	65	59	46
19																		53	50	65	63	43
20																			80	47	42	20
22																				42	38	18
23																					68	55
24																						66

3.3 Periphyton Community Structure

by Loren L. Bahls

PERIPHYTON COMMUNITY STRUCTURE IN THE CLARK FORK RIVER AND ITS TRIBUTARIES

SUMMER 1987

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PERIPHYTON COMMUNITY STRUCTURE

Methods

Composite periphyton samples were collected from natural substrates at all 28 ambient water stations from August 11-21, 1986. Different substrates (e.g., rocks, silt, aquatic plants) were sampled in proportion to their importance at a given site. Algae were also collected from various water depths and at various current velocities. Samples were preserved with Lugols solution.

Soft-bodied (non-diatom) algae were identified to genus under a light microscope at 400x. Together with the diatoms, the relative abundance of each algal genus in each sample was estimated by volume, based on field notes and microscopic examination.

The periphyton samples were then processed in concentrated sulfuric acid and potassium dichromate in order to oxidize and remove organic matter, leaving behind empty diatom frustules and other inorganic constituents. This "cleaned" material was mounted on glass slides in Hyrax and examined under 1000x for diatoms. Each slide was first scanned and a species list was prepared. Between 358 and 451 diatom frustules were then counted at random in each Hyrax mount and the percent relative abundance of each species was calculated. Total species, species counted and shannon diversity were then calculated for each diatom association. Also calculated was the percent relative abundance of diatoms in the three pollution tolerance groups of Lange-Berfalot (1979).

RESULTS

Results of the periphyton composition analyses are presented in Tables 1 through 3.

The summer 1986 algal flora of the Clark Fork River and its major tributaries was dominated by green algae (Chlorophyta),

diatoms (Bacillariophyta) and blue-green algae (Cyanophyta). Other groups represented were euglenoid algae (Euglenophyta), yellow-green algae (Chrysophyta), and red algae (Rhodophyta).

Cladoaphora was the most consistently abundant genus of non-diatom algae in the river. Peak abundance of this alga was registered from Gold Creek to Missoula and again in the reach between Superior and the Flathead River. Other non-diatom algae were locally abundant or widely distributed up and down the river but in smaller number.

Diatoms were recorded at every station. Low species diversity and a large percentage of pollution tolerant diatoms indicate significant ecological stress in Silver Bow Creek and the upper Clark Fork River. Very low species diversity values were recorded at Turah and at Harper Bridge (between the mouth of the Bitterroot and the discharge from Stone Container). At each of these sites, however, there was a very small percentage of pollution tolerant diatoms, indicating relatively good water quality. A preponderance of *Epithemia sorex* and *Cymbella affinis*, both pollution sensitive species, was responsible for the low diversity values at Turah and Harper Bridge, respectively.

Table 1. Estimated relative abundance (by volume) of diatoms and genera of other algae in periphyton samples collected from the Clark Fork River and tributaries, August 11-21, 1986.

	STATION													
	01	02	03	04	05	06	07	08	09	10	11	12	13	14
CHLOROPHYTA (green algae)														
Ankistrodesmus sp.					R		R	C	R	R				
Botryococcus sp.														
Bulbochaete sp.														
Chaetophora sp.														C
Chara sp.														
Cladophora sp.				C			C	A	A	VA	VA	VA	VA	
Closterium sp.						R					R	R		
Cosmarium sp.				C	A	C	C	C	C	C		R		VC
Enteromorpha sp.									A	C		A		
Gloeocystis sp.					C	R		R						
Gongrosira sp.														VC
Hormidium sp.			C											
Mougeotia sp.														
Nephrocytium sp.						R								
Oedogonium sp.														
Palmella sp.	C	A	C											
Pediastrum sp.				R	R			R	R					
Protococcus sp.								R						
Rhizoclonium sp.					R									
Scenedesmus sp.	C	C	VC	R	A	VC	C	VC	VC	VC	C	C	C	C
Spirogyra sp.														A
Stigeoclonium sp.	VC	R	R	A	R		A	A		R		R	R	R
Tetraspora sp.				VC	R	VC								
Ulothrix sp.													C	R
EUGLENOPHYTA (euglenoid algae)														
Euglena sp.									R					
CHRYSOPHYTA (yellow-green algae)														
Dinobryon sp.														
Tribonema sp.			R		R						R			
BACILLARIOPHYTA (diatoms)	VC	C	VC	VA	VA	VA	VA	VA	VA	A	VA	VA	VA	VA

Table 1. Continued.

	STATION													
	01	02	03	04	05	06	07	08	09	10	11	12	13	14
CYANOPHYTA (blue-green algae)														
Chamaesiphon sp.					R									
Chroococcus sp.	VA	VA	VVA		VA		R							
Merismopedia sp.								R						
Nostoc sp.						VC	R	VC	VC	A	A	VC		
Oscillatoria sp.		R		VC	VVA	A	VC	C	R	C	C		R	
Phormidium sp.			R	VC	VC	C	VA			R		R		
Rivularia sp.				R							VC	C	A	A
Synechocystis											R			
Tolypothrix sp.														
RHODOPHYTA (red algae)														
Audouinella sp.						R					R	R	VC	R

R = rare; C = common; VC = very common; A = abundant; VA = very abundant; VVA = very, very abundant

Table 1. Estimated relative abundance (by volume) of diatoms and genera of other algae in periphyton samples collected from the Clark Fork River and tributaries, August 11-21, 1986.

	STATION													
	15	16	18	19	20	22	23	24	25	26	27	28	29	30
CHLOROPHYTA (green algae)														
Ankistrodesmus sp.	R					R			R	R	C	C	R	VC
Botryococcus sp.													R	
Bulbochaete sp.										VC				
Chaetophora sp.														
Chara sp.										VC				
Cladophora sp.	VA	VA	A	C	A	A	A	VA	VA		A			
Closterium sp.			R	C	R	R	R		R	R	R			R
Cosmarium sp.	VC	VC	C	C	VC	C	C	C	C	C	C	C	R	R
Enteromorpha sp.														
Gloeocystis sp.														
Gongrosira sp.											R			R
Hormidium sp.														
Mougeotia sp.										A	R	R	VC	VC
Nephrocytium sp.														
Oedogonium sp.					R							R		C
Palmella sp.														
Pediastrum sp.		R		C	R		R	R	R	R	R			R
Protococcus sp.														
Rhizoclonium sp.														
Scenedesmus sp.	R	C	C	VC	VC	C	C	VC	VC	C	C	C	C	C
Spirogyra sp.												R	VA	VA
Stigeoclonium sp.	C		R	R	C	C		R	A	C	C	C		VC
Tetraspora sp.														
Ulothrix sp.						VC								
EUGLENOPHYTA (euglenoid algae)														
Euglena sp.														
CHRYSOPHYTA (yellow-green algae)														
Dinobryon sp.														R
Tribonema sp.														
BACILLARIOPHYTA (diatoms)	VA	VA	VVA	VA	VVA	VVA	VVA	VVA	VVA	A	A	VA	VA	VA

Table 1. Continued.

	STATION													
	15	16	18	19	20	22	23	24	25	26	27	28	29	30
CYANOPHYTA (blue-green algae)														
Chamaesiphon sp.														
Chroococcus sp.														
Merismopedia sp.										C			R	
Nostoc sp.												R	C	VC
Oscillatoria sp.			C	A		C				A	C		R	
Phormidium sp.		R	C	VA	R		R					R	C	C
Rivularia sp.	VC	C	C				C	C	C	VC	C	VC		C
Synechocystis														
Tolypothrix sp.											C	A		VC
RHODOPHYTA (red algae)														
Audouinella sp.	C	C	VC				C							

R = rare; C = common; VC = very common; A = abundant; VA = very abundant; VVA = very, very abundant

Table 2. Percent relative abundance (by cell numbers) of diatom species in periphyton samples collected from the Clark Fork River and tributaries, August 11-21, 1986.

SPECIES	STATION											
	01	02	03	04	05	06	07	08	09	10	11	12
Achnanthes affinis											0.3	
A. clevei												
A. deflexa						2.0	0.3		2.1	0.2		
A. lanceolata	P	P	0.3		5.0	0.2	0.6	0.5	0.8	0.7	0.3	0.2
A. lapponica						0.2						
A. linearis												
A. marginulata					P							
A. microcephala												
A. minutissima	35.6	41.9	24.6		6.8	47.4	8.1	24.9	46.5	4.4	2.5	
A. pellucida												
A. peragalli												
A. subrostrata												
Amphipleura pellucida												
Amphora inariensis												0.2
A. libyca												0.2
A. pediculus												
veneta				13.6	0.2	0.2	5.9	0.5				
A. sp.												
Asterionella formosa												
Caloneis amphisbaena												
C. bacillum				0.3				0.7	0.3	0.4	P	
Cocconeis diminuta												
C. disculus												
C. placentula	P	P	1.3	1.3	1.4	0.2	0.3	2.5	P	1.6	11.1	4.8
C. pediculus		0.3						P	P	0.4	1.3	9.4
Cyclotella comensis												
C. kutzingiana												
C. meneghiniana	P				3.2	0.5	12.3	0.7	2.1	8.0	0.5	1.0
C. ocellata												
C. pseudostelligera												
Cymatopleura solea				P				P	P	P		

Table 2. Continued.

SPECIES	STATION											
	01	02	03	04	05	06	07	08	09	10	11	12
Cymbella affinis						0.2					0.5	0.2
C. caespitosa												
C. cistula												
C. delicatula												
C. descripta						1.0	P					
C. mexicana												0.2
C. microcephala						4.9						
C. minuta		P			12.1	9.3	5.0	3.2	4.5	0.9	1.0	P
C. prostrata												
C. reichardtii								1.0		1.1	0.3	
C. sinuata					0.5	1.2	0.6	1.0	1.9	1.6	6.3	0.5
C. sp.							0.3					
Denticula elegans									0.3			
D. sp.								P				
Diatoma tenue												
D. vulgare	P								0.3	0.4		P
Diploneis sp.												
Epithemia adnata												
E. sorex				0.3			P	0.2	P	7.5	35.4	65.9
E. turgida												0.2
Fragilaria capucina	4.5	1.0	0.3	1.3	3.2	0.7	1.7	2.7	5.1	7.3	1.5	1.2
F. construens	P	P			4.3	0.5	3.9	0.7	2.7	3.3	0.3	P
F. crotonensis												
F. leptostauron						0.5	P	P	0.5	0.2		0.2
Frustulia rhomboides												
Gomphoneis herculeana												
G. eriense	P											
G. septa												
G. sp.								P				
Gomphonema angustatum												
G. clavatum				1.5			P		P	0.2		
G. minutum												
G. olivaceum						1.0	0.8	1.2	0.5	0.9	2.5	1.5
G. parvulum	P			0.8	0.9	0.2	1.1	0.7	2.4	1.8	0.3	

Table 2. Continued.

SPECIES	STATION 01	02	03	04	05	06	07	08	09	10	11	12
Gomphonema pseudoaugur												
G. tergestinum												
G. truncatum							0.3					
G. sp.					0.5							
Hannaea arcus			P		P	P	0.6			P		
Melosira granulata				P								
M. varians					0.5		0.3					
M. sp.												
Meridion circulare			P			0.2						0.2
Navicula arvensis	0.3	P			1.6	1.0	P	P	0.3		P	
N. atomus	26.2	29.3	49.4	0.3	1.6	0.5	1.7	2.2	P	1.3		0.5
N. aurora												
N. bryophila												
N. capitata v. luneburgensis												
N. capitatoradiata	0.3										0.3	
N. cocconeiformis												
N. clementis		0.3										
N. cryptocephala					P		0.3	0.5				
N. cryptotenella						2.7	0.6	4.4	0.8	1.7	1.0	P
N. decussis	P				0.5			P				
N. difficillima												
N. elginensis												
N. exigua												
N. fracta												
N. gallica												
N. gregaria								P	0.3			
N. libonensis												
N. lanceolata					0.7			P			0.5	
N. menisculus				P		P					0.3	
N. minima	27.5	23.8	23.0	15.2	3.4	0.5	1.7	4.0	3.2	15.3	4.1	
N. mutica		P							P			
N. pelliculosa												
N. phyllepta												
N. pseudoscutiformis												
N. pupula					P			P	0.3	P		0.2

Table 2. Continued.

SPECIES	STATION 01	02	03	04	05	06	07	08	09	10	11	12
Navicula radiosa										P		
N. schoenfeldii												
N. subhamulata								P				
N. subminuscula												
N. subrotundata												
N. (tenelloides ?)												
N. tripunctata			P			0.5	0.3					
N. trivialis							P	0.2	P			
N. tuscula												
N. veneta				0.3		0.5		0.2	1.1	P	0.5	0.2
N. viridula												
N. sp.								0.2				
Neidium bisulcatum									P			
Nitzschia acuta					0.2							
N. acidoclinata		P										
N. acicularis					0.5	0.7	1.1	5.4	2.7	2.7	P	P
N. amphibia				17.7	P		1.1	P	P	0.7		
N. delognei												P
. dissipata			P	P	1.4	4.2	0.6	5.7	3.7	6.7	1.3	1.9
N. frustulum				27.5	0.7	0.5	4.7	1.7	1.9	14.6	26.8	1.2
N. gandersheimiensis												
N. gracilis					0.5				P		P	
N. intermedia						0.2						
N. linearis		P	P		2.7	0.5	0.3	0.5	1.6	0.4	0.5	0.5
N. palea	4.3	0.3	0.3	1.0	13.0	2.0	17.3	15.1	5.6	3.3	P	1.0
N. paleacea		0.3	P	10.3	30.1	13.3	25.1	17.3	7.4	9.5	0.8	3.9
N. romana				P	P		0.6	1.0		1.8	P	0.7
N. sinuata												
N. sp #1												
N. sp #2												
N. sp.					1.4	0.2		0.2				
Pinnularia obscura		P										
Rhopalodia gibba					0.2							
R. gibberula			P									
Rhoicosphenia curvata	P			8.7	0.5		0.3			0.2	P	2.2
Stauroneis smithii												

Table 2. Continued.

SPECIES	STATION											
	01	02	03	04	05	06	07	08	09	10	11	12
Stephanodiscus astraea												
S. subtilis								P	P			0.2
S. sp.												
Surirella angustata	1.6	1.0	1.0		P	0.5	1.4	P	0.3	0.2		
S. ovata	0.3	2.0	1.3	P	2.7	0.5	0.6	0.5	0.8	0.4		
Synedra filiformis						0.2	0.3					
S. mazamaensis												
S. ulna		P		P	P	0.5	0.3	P	0.3	0.7		1.5
Tabellaria sp.												
Unknown						0.2						
Total Species	19	20	17	22	37	39	40	45	41	38	32	32
Species Counted	9	10	8	15	29	37	34	30	29	33	25	26
Frustules Counted	374	399	391	389	439	407	358	405	376	451	395	413
Species Diversity (Shannon)	2.107	1.871	1.702	2.869	3.629	3.051	3.664	3.633	3.232	4.073	2.885	2.177

P means present in the sample but not encountered during the proportional count.

Table 2. Percent relative abundance (by cell numbers) of diatom species in periphyton samples collected from the Clark Fork River and tributaries, August 11-21, 1986.

SPECIES	STATION											
	13	14	15	16	18	19	20	22	23	24	25	26
Achnanthes affinis						0.2						
A. clevei			P					0.3				1.9
A. deflexa		1.2			P	7.2	0.2	0.3	0.2	0.2		6.4
A. lanceolata	P		0.2			1.7	P	0.5	0.7	0.2	1.3	5.6
A. lapponica												P
A. linearis												0.3
A. marginulata												0.6
A. microcephala												
A. minutissima	1.1	19.7	6.8	8.4	3.6	24.0	2.2	3.1	4.7	19.5	29.6	22.6
A. pellucida												0.6
A. peragalli												P
A. subrostrata												0.3
Amphipleura pellucida		0.2		0.3								
Amphora inariensis												0.3
A. libyca												
A. pediculus		0.9	0.5	1.8	0.7	0.2	0.2		P	0.5	0.3	4.5
A. veneta												
A. sp.										0.5		
Asterionella formosa												P
Caloneis amphisbaena												
C. bacillum									P			
Cocconeis diminuta												3.9
C. disculus												0.3
C. placentula	3.2	12.3	7.5	5.6	1.8	12.7	0.9	3.1	4.5	5.0	3.5	5.0
C. pediculus	0.8	1.2	1.0	1.5		1.2		P	0.2			
Cyclotella comensis												
C. kutzingiana												
C. meneghiniana	P					0.5	0.2	0.3	0.7	0.5	1.8	
C. ocellata												4.7
C. pseudostelligera												

Table 2. Continued

SPECIES	STATION											
	13	14	15	16	18	19	20	22	23	24	25	26
Cymatopleura solea			P									
Cymbella affinis	18.5	14.3	17.3	7.7	64.4	4.6	78.9	57.3	51.9	23.6	5.3	4.2
C. caespitosa		0.5	0.2	P		P	0.2	0.5			0.3	0.3
C. cistula				0.3		0.2						
C. delicatula												0.3
C. descripta												
C. mexicana						P	0.2	P				
C. microcephala		3.2	P	0.3	0.2							5.6
C. minuta	P	1.2	1.0	1.3	0.2	4.1	P	0.5	0.2	P	0.8	0.3
C. prostrata						P						0.3
C. reichardtii			P		0.7	0.2						
C. sinuata	0.8	2.1	1.5	1.0		8.2	0.9	1.0	5.0	7.5	4.5	0.8
C. sp.												
Denticula elegans												
D. sp.												
Diatoma tenue			P	P								
D. vulgare	0.3	0.7	0.5	2.0	0.5	0.2	2.9	1.3	0.7	4.6	1.3	0.3
Diploneis sp.		0.2										
Epithemia adnata		1.2	0.5	0.5								
E. sorex	66.2	3.5	36.7	39.0	2.9		2.0	6.9	10.7	16.3	26.6	P
E. turgida		0.2		0.8	P					0.2	0.5	
Fragilaria capucina	0.5	2.8	1.9	4.3	0.7	1.0		0.8	0.2	1.0	0.5	4.2
F. construens	0.8	3.2	1.7	2.0	0.7	0.2	0.4	0.5	1.2	1.4	1.5	2.8
F. crotonensis												
F. leptostauron		1.6	0.7	0.8	0.2	0.2		P	P	P	1.8	2.5
Frustulia rhomboides												
Gomphoneis herculeana												
G. eriense				0.3	0.2	0.5	0.2	P	0.2		0.5	
G. septa		0.2										3.6
G. sp.		1.2										
Gomphonema angustatum				0.3		2.2	0.7	0.3				1.1
G. clavatum												
G. minutum						2.6			0.2	0.5	0.5	
G. olivaceum	0.8	1.2	1.2	2.3	1.1		P	0.3	P	0.7	0.3	P
G. parvulum			P		0.2							P

Table 2. Continued

SPECIES	STATION											
	13	14	15	16	18	19	20	22	23	24	25	26
Gomphonema pseudoaugur												
G. tergestinum										P	P	
G. truncatum												
G. sp.		1.6										
Hannaea arcus												
Melosira granulata												
M. varians						0.5		P				
M. sp.												
Meridion circulare									P			
Navicula arvensis					0.2	0.2						
N. atomus			0.2	0.3		0.2		0.3				0.3
N. aurora	0.3											
N. bryophila		0.2										
N. capitatoradiata		1.4	0.5	P	0.9	6.2	1.5	1.3	1.7	1.9	4.3	1.1
N. capitata v. luneburgensis												
N. cocconeiformis												
N. clementis												
N. cryptocephala						P	0.2					
N. cryptotenella		2.8	4.4	4.1	1.8	2.2	0.2	2.3	1.7	1.4	2.3	1.1
N. decussis						0.2	0.2					0.3
N. difficillima												
N. elginensis				0.3								
N. exiqua												
N. fracta												
N. gallica												
N. gregaria												
N. libonensis												0.3
N. lanceolata												
N. menisculus		0.2										P
N. minima						1.2	P	0.3				1.4
N. mutica												0.3
N. pelliculosa			0.5									
N. phyllopta												
N. pseudoscutiformis												P
N. pupula		0.2				0.2	0.2		P			0.3

Table 2. Continued

SPECIES	STATION											
	13	14	15	16	18	19	20	22	23	24	25	26
Navicula radiosa												
N. schoenfeldii						1.0	0.2	P		P		
N. subhamulata												
N. subminuscula						0.2						
N. subrotundata												0.3
N. (tenelloides ?)		0.2										
N. tripunctata	0.3	0.5	1.0	0.5	P	0.5	0.7	0.8	0.2	0.2	0.3	
N. trivialis						P						P
N. tuscula												P
N. veneta	1.1	1.4	0.2	0.5	0.7	1.0		0.5	0.7	1.0	0.3	0.3
N. viridula				P								
N. sp.		0.2		0.3								0.3
Neidium bisulcatum												
Nitzschia acuta												
N. acidoclinata												
N. acicularis			0.2	0.3		P		P		0.7	0.3	0.3
N. amphibia									P			0.3
N. delognei												
. dissipata	0.8	2.8	1.2	1.8	1.8	0.5	0.9	3.6	1.7	0.5	1.0	1.1
N. frustulum	2.4	0.9	6.6	3.6	5.0	7.7	0.4	2.6	1.0	3.8	5.5	P
N. gandersheimiensis												
N. gracilis		0.5		0.3	0.5		P	0.3				
N. intermedia												
N. linearis				0.3	0.2		P	P	P			
N. palea		0.2				1.2	P	0.3	0.5	0.2	0.5	1.4
N. paleacea	1.6	5.8	3.9	3.3	9.5	3.1	0.2	3.6	1.5	3.6	2.8	3.9
N. romana		0.5		P	0.7	0.2	2.6	3.6	1.5	2.2	0.3	
N. sinuata												
N. sp. #1												1.9
N. sp. #2												0.6
N. sp.		0.2										
Pinnularia obscura												
Rhopalodia gibba	0.3		0.2	0.3	P							
R. gibberula												
Rhoicosphenia curvata		0.7	0.2	0.3	P	1.2	0.2	0.5	0.5	0.2		
Stauroneis smithii												

Table 2. Continued

SPECIES	STATION											
	13	14	15	16	18	19	20	22	23	24	25	26
Stephanodiscus astraea												
S. subtilis				0.3					0.5		0.3	
S. sp.												
Surirella angustata				P								
S. ovata			0.2	0.5	P							
Synedra filiformis												
S. mazamaensis		0.2	0.2	0.3	0.2							
S. ulna	0.3	6.0	1.0	2.8	0.5	0.5	2.2	3.6	6.5	1.9	2.0	1.7
Tabellaria sp.												P
Unknown												
Total Species	21	42	39	44	33	45	34	38	36	32	31	58
Species Counted	18	42	31	38	27	39	27	30	27	28	30	46
Frustules Counted	373	431	411	392	444	417	456	391	401	416	399	359
Species Diversity (Shannon)	1.804	4.188	3.295	3.606	2.271	3.990	1.595	2.752	2.827	3.489	3.365	4.439

P means present in the sample but not encountered during the proportional count.

Table 2. Percent relative abundance (by cell numbers) of diatom species in periphyton samples collected from the Clark Fork River and tributaries, August 11-21,1986.

SPECIES	STATION			
	27	28	29	30
Achnanthes affinis				
A. clevei	0.5	0.5	1.1	3.0
A. deflexa	1.0	0.3	1.1	2.2
A. lanceolata	0.2	1.6	12.0	7.6
A. lapponica				
A. linearis				0.3
A. marginulata				
A. microcephala	P			
A. minutissima	9.7	17.3	9.3	12.2
A. pellucida				
A. peragalli				
A. subrostrata				
Amphipleura pellucida	P	0.3	0.2	
Amphora inariensis	0.5			
A. libyca				
A. pediculus	1.0	1.8	1.6	2.7
A. veneta				
. sp.				
Asterionella formosa			0.2	
Caloneis amphisbaena		0.3		
C. bacillum				0.3
Cocconeis diminuta		0.5	1.1	P
C. disculus				
C. placentula	5.2	0.8	0.2	3.8
C. pediculus			0.7	P
Cyclotella comensis	0.7	1.8	0.7	0.8
C. kutzingiana		0.3	0.2	
C. meneghiniana	1.5	2.6	0.2	2.4
C. ocellata	1.0	1.8	1.4	2.2
C. pseudostelligera			0.5	1.4
Cymatopleura solea		P		P

Table 2. Continued.

SPECIES	STATION			
	27	28	29	30
Cymbella affinis	20.1	7.6	24.6	12.5
C. caespitosa	1.0	P	0.9	0.8
C. cistula			0.2	
C. delicatula				
C. descripta				
C. mexicana				
C. microcephala	7.4	1.3	0.5	
C. minuta	1.0	0.8	0.5	P
C. prostrata	P		P	
C. reichardtii		0.3		
C. sinuata	1.7	2.4	P	0.5
C. sp.				
Denticula elegans				
D. sp.				
Diatoma tenue		0.3		0.3
D. vulgare	0.7	0.3	P	1.1
iploneis sp.				
Epithemia adnata	0.5			
E. sorex	7.7	3.9	1.6	0.5
E. turgida				
Fragilaria capucina	3.5	1.6	2.0	1.9
F. construens	1.7	11.3	9.7	3.8
F. crotonensis		0.5	6.3	0.3
F. leptostauron	1.0	3.7	0.7	0.5
Frustulia rhomboides		0.3		
Gomphoneis herculeana	P	0.5		
G. eriense		0.5		
G. septa	P			
G. sp.				
Gomphonema angustatum	P	0.3		
G. eroemse				
G. minutum	P		1.1	1.4
G. olivaceum		1.3	0.2	P
G. parvulum	0.2		0.7	

Table 2. Continued.

SPECIES	STATION 27	28	29	30
Gomphonema pseudoaugur		P		
G. tergestinum				
G. truncatum				
G. sp.				0.5
Hannaea arcus				
Melosira granulata			2.9	1.9
M. varians			0.9	0.5
M. sp.				0.5
Meridion circulare				
Navicula arvensis				
N. atomus			0.2	
N. aurora				
N. bryophila				
N. capitata v. luneburgensis				P
N. capitatoradiata	3.2	5.2	0.2	2.4
N. cocconeiformis				0.3
N. clementis				
N. cryptocephala				
N. cryptotenella	2.7	2.1	0.9	1.9
N. decussis				
N. difficillima		0.3	0.2	
N. elginensis				
N. exigua		0.3		
N. fracta		0.3		
N. gallica		P		
N. gregaria				
N. libonensis				
N. lanceolata		0.3		
N. menisculus		0.3		P
N. minima	0.2	0.8	0.2	0.5
N. mutica				
N. pelliculosa				
N. phyllepta				P
N. pseudoscutiformis	0.2	0.3		
N. pupula				

Table 2. Continued.

SPECIES	STATION			
	27	28	29	30
Navicula radiosa				
N. scoenfeldii				
N. subhamulata				
N. subminuscula		0.3		
N. subrotundata				
N. (tenelloides ?)				
N. tripunctata	1.7	0.3	0.2	0.3
N. trivialis				
N. tuscula				
N. veneta	0.5	1.3	1.1	0.5
N. viridula				
N. sp.		0.3		
Neidium bisulcatum				
Nitzschia acuta				
N. acidoclinata				
N. acicularis		0.3	0.2	
N. amphibia				
N. delognei				
N. dissipata	1.5	5.0	2.5	6.5
N. frustulum	1.5	3.4	1.4	1.4
N. gandersheimiensis				0.3
N. gracilis		P	0.2	1.9
N. intermedia		0.3		
N. linearis		P		
N. palea	0.2	0.3	1.8	0.8
N. paleacea	1.2	3.7	2.5	3.8
N. romana	0.7	0.5	2.3	7.3
N. sinuata	P	0.3	0.7	
N. sp. #1				
N. sp. #2				
N. sp.		0.3	0.5	0.8
Pinnularia obscura				
Rhopalodia gibba		0.3		
R. gibberula				
Rhoicosphenia curvata	P	0.3		P
Stauroneis smithii		0.3		

Table 2. Continued.

SPECIES	STATION			
	27	28	29	30
Stephanodiscus astraea				P
S. subtilis		0.5	0.7	0.8
S. sp.				
Surirella angustata				
S. ovata		0.3		
Synedra filiformis		0.3	0.2	1.6
S. mazamaensis	0.2	0.3	0.2	2.7
S. ulna	17.9	5.5	0.5	P
Tabellaria sp.	P	0.3		
Unknown				
Total Species	45	67	53	56
Species Counted	36	61	50	44
Frustules Counted	403	382	443	368
Species Diversity (Shannon)	3.980	4.691	4.209	4.664

P means present in the sample but not encountered during the proportional count.

Table 3. Percent relative abundance of diatoms in the three pollution tolerance groups of Lange-Bertalot (1979). Group 1 diatom species are "most tolerant" of pollution; Group 2 diatom species are "less tolerant", and Group 3 species are "sensitive".

STATION		Group 1	Group 2	Group 3
01	(Silver Bow Creek)	58.3	6.7	35.6
02	(Silver Bow Creek)	53.4	4.3	42.5
03	(Silver Bow Creek)	72.7	2.9	24.6
04	(Pond 2 Discharge)	31.2	56.8	12.1
05	(Mill-Willow Bypass)	20.7	61.3	18.3
06	(Warm Springs Creek)	5.4	35.2	59.0
07		28.0	55.1	17.3
08		22.7	38.5	38.4
09		12.9	27.0	60.4
10		22.4	47.8	30.2
11		4.9	33.3	62.0
12		3.2	7.7	88.8
13		1.4	4.5	94.2
14	(Blackfoot River)	7.6	21.4	70.8
15		1.9	19.1	78.7
16		3.6	18.6	78.4
17	(Missoula WWTP)			
18		1.6	18.8	79.7
19	(Bitterroot River)	4.5	28.4	67.0
20		2.2	3.1	94.5
21	(Stone Container)			
22		5.0	12.2	83.4
23		7.7	7.7	83.9
24		3.1	13.1	83.6
25		2.8	19.6	78.4
26	(Flathead River)	5.1	25.5	69.9
27		19.0	22.2	58.3
28		8.2	25.3	67.6
29		4.5	22.5	73.0
30		2.1	26.3	71.3

Reference: Lange-Bertalot, Horst. 1979. Pollution tolerance of diatoms as a criterion for water quality estimation. Nova Hedwigia 64:285-304.

3.4 Diel Dissolved Oxygen and Temperature

by Mark A. Kerr

DISSOLVED OXYGEN IN THE CLARK FORK RIVER NEAR THE MISSOULA WASTEWATER TREATMENT PLANT AND STONE CONTAINER CORPORATION

July 8-9 and August 5-6, 1986

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ABSTRACT

A study of dissolved oxygen in the Clark Fork River above and below discharges of the Missoula Wastewater Treatment Plant (WWTP) and the Stone Container Corporation Frenchtown kraft mill (formerly Champion International) was conducted in July and August, 1986. The objective of the study was to determine whether the wastewater discharges from the Missoula WWTP and Stone Container kraft mill had a measurable impact on dissolved oxygen concentrations in the Clark Fork River.

The study involved two surveys, each 24 hours long, during which water temperature and dissolved oxygen measurements were made at regular intervals at six stations on the Clark Fork River. Measurements of barometric pressure were made at a location central to the six river stations. One survey was conducted during a period of high wastewater discharge from Stone Container (512:1 instream dilution). The second survey occurred during a period of low wastewater discharge (1067:1 instream dilution). Water temperature and barometric pressure measurements were used to calculate a time-weighted average saturation concentration of dissolved oxygen. A time-weighted average dissolved oxygen concentration was calculated from field measurements of dissolved oxygen. Changes between sites in the average saturation concentration and the average dissolved oxygen concentration were calculated for both surveys, as were changes at each site between the two surveys.

The time-weighted average saturation concentration did not change between any two adjacent sites by more than 0.08 mg/l during either survey. This indicated that barometric pressure and water temperature were similar at all sites. Using the data collected during low wastewater discharge as a basis for comparison, the largest change during high wastewater discharge occurred between Huson and Alberton (0.07 mg/l increase in the average saturation concentration). This indicated that changes in water temperature and barometric pressure between the two surveys were similar at all sites.

The time-weighted average dissolved oxygen concentration varied significantly by site and survey. During low wastewater discharge, it tended to increase in a downstream direction; during high wastewater discharge, it tended to decrease in a downstream direction. Again, using data collected during low wastewater discharge as a baseline, the largest change between two adjacent sites during high wastewater discharge occurred between Shuffields and Harper Bridge (0.46 mg/l decrease) and Huson and Alberton (0.46 mg/l decrease).

The theoretical net oxygen loss during high wastewater discharge relative to low discharge was greatest at Alberton, and amounted to 0.90 mg/l. This resulted from an increase of 0.52 mg/l in the average saturation concentration and a decrease of 0.38 mg/l in the dissolved oxygen concentration.

Because the flow of the Clark Fork River and weather conditions during the two surveys were quite different, the estimated losses of dissolved oxygen during high wastewater discharge cannot necessarily be attributed to the volume of wastewater discharged by Stone Container. However, this method or a more refined version of it does appear to have a practical application.

ACKNOWLEDGEMENTS

I would like to thank Erich Weber and Gary Ingman of the State of Montana Water Quality Bureau for their assistance in the field collecting water temperature and dissolved oxygen data during both 24-hour surveys, and for reviewing the study plan and the final report. I would also like to thank Pamela Brewster for her patience in editing and typing the various draft versions of the report.

1. INTRODUCTION

The monitoring of dissolved oxygen in the Clark Fork River in the vicinity of the Missoula Wastewater Treatment Plant (WWTP) and the Stone Container Corporation kraft mill in Frenchtown was part of an intensive, two-year water quality survey conducted to determine the impact of the Stone Container kraft process wastewater discharge and other sources of pollutants on the Clark Fork River from above Missoula to the Idaho border. The resulting Environmental Impact Statement (EIS) identified several problems with dissolved oxygen surveys conducted in the summers of 1984 and 1985. One problem was that monitoring had not occurred during a period of high wastewater discharge from Stone Container. A second problem, identified by several EIS reviewers, was that dissolved oxygen data would have been more meaningful if presented in terms of saturation concentration and percent oxygen saturation. This study was designed to address these problems and to quantify changes in dissolved oxygen concentrations during a period of high wastewater discharge (low instream dilution) and a period of low wastewater discharge (high instream dilution) from Stone Container Corporation.

2. OVERVIEW

The concentration of dissolved oxygen in a body of water is determined by a complex set of chemical, physical, and biological processes. Predictive and mass balance equations include "input" factors due to reaeration and photosynthesis and "depletion" factors such as advective flow, carbonaceous oxidation, nitrogenous oxidation, benthic demands, and algal respiration. Other factors which influence these processes are water temperature, atmospheric pressure, channel morphology, solar radiation, turbidity, and community productivity.

Two variables, water temperature and atmospheric pressure, determine the amount of oxygen water will hold. The saturation concentration of dissolved oxygen at sea level (Cs) can be predicted by the following equation:

$$Cs = 14.65 - 0.41022T + 0.00791T^2 - 0.000077774T^3$$ (Mills et al., 1982) (1)

where T is the water temperature in ^{o}C.

Barometric pressure affects Cs as follows:

$$Cs' = Cs \times (Pb-Pv/760-Pv)$$ (Mills et al., 1982) (2)

where

Cs = saturation concentration at sea level at the temperature of the water, in mg/l

Pb = barometric pressure at altitude, in mm Hg.

Pv = saturation vapor pressure of water at the river temperature, in mm Hg.

An expression of the relationship between the dissolved oxygen concentration and the saturation concentration is the percent oxygen saturation determination:

$$\%\ \text{saturation} = \frac{\text{dissolved oxygen concentration}}{\text{saturation concentration}} \times 100 \quad (3)$$

Although "percent oxygen saturation" is a convenient way of expressing the relationship between the dissolved oxygen concentration and the saturation concentration, the dynamics of

dissolved oxygen can be better understood by analyzing changes which occur in the two component measures of the percent saturation determination over a period of time or along a reach of river. Results of this study will be discussed not only in terms of percent oxygen saturation, but also in terms of the changes which occurred in its component measures -- the dissolved oxygen concentration and the saturation concentration.

3. OBJECTIVES AND STUDY DESIGN

The objective of this study was to determine whether wastewater discharges from the Missoula WWTP and the Stone Container Corporation kraft mill caused measurable changes in the dissolved oxygen concentration in the Clark Fork River. The study involved:

1. two 24-hour surveys, one conducted during a period of high wastewater discharge from Stone Container (low instream dilution) and one conducted during a period of low discharge (high instream dilution); and
2. frequent measurements of water temperature and dissolved oxygen at six sites on the Clark Fork River upstream and downstream of the Missoula WWTP and the Stone Container discharges; and
3. measurements of barometric pressure at a location central to six monitoring sites for calculating saturation concentrations.

The analysis of changes which occurred between sites during both surveys and at a site between two surveys was based on the following rationale. The saturation concentration of water is a function of water temperature and barometric pressure (Equation 1). It can be regarded as the dissolved oxygen concentration expected in a system void of any other influence. Realistically, the measured dissolved oxygen concentration differs from the saturation concentration because of photosynthesis, respiration, chemical oxidation, reaeration, and other factors. However, the saturation concentration can be used to estimate the dissolved oxygen concentration, even though the estimate may not be very precise. Previous monitoring of the Clark Fork River has shown that the maximum and minimum dissolved oxygen concentrations occurred at day and at night, respectively, because of the dominating influences of photosynthesis and respiration. Equation 1 would have predicted the opposite - higher dissolved oxygen concentrations at night due to the higher saturation point of cool water and lower dissolved oxygen concentrations during the day as water temperatures increased and the saturation

concentration decreased.

Because the saturation concentration is not a very good estimator of the dissolved oxygen concentration for an instantaneous measurement, a series of measurements over a period of 24 hours permitted the calculation of a time-weighted average concentration for both parameters. A time-weighted average was necessary to eliminate differences in sampling time intervals. That is, a measurement made during a two-hour time interval could not be considered equivalent to a measurement made during a three-hour time interval when calculating the "average" concentration. Therefore, all measurements were weighted by their respective time intervals (Appendix A).

The time-weighted average saturation concentration can be used to calculate the weight of dissolved oxygen expected to pass a monitoring station, based on water temperature and barometric pressure, during the period of monitoring. Consider the following equation:

$$W = Qc \times 5.39 \times C \quad \text{(Kittrell, 1969)} \quad (4)$$

where:

W = weight of constituent in pounds per day passing a given point
Qc = flow in cubic feet per second
C = concentration of dissolved oxygen in milligrams per liter

The use of a time-weighted average saturation concentration for (C) would account for fluctuations in water temperature and barometric pressure that an instantaneous measurement could not, and would yield a weight in pounds per day of dissolved oxygen estimated to pass a given point. Similarly, the time-weighted average dissolved oxygen concentration would yield the pounds per day of dissolved oxygen which actually passed a given point, accounting for the influences of photosynthesis and respiration. Thus, comparing the time-weighted average saturation concentration and the time-weighted average dissolved oxygen concentration is really no different than comparing the daily loads based on the two averages.

Data collected during the period of low wastewater discharge from Stone Container served as a baseline for comparing data collected during the period of high wastewater discharge. Time-weighted averages for the saturation concentration and the dissolved oxygen concentration from the two surveys were compared to determine whether the dissolved oxygen concentration deviated from the saturation concentration more or less during high discharge than during low discharge, and by how much. Finally, changes in the parameters between sites were calculated to determine whether dissolved oxygen was lost or gained between stations during high discharge compared to changes measured during low discharge, and whether these gains or losses could be explained by changes in water temperature and barometric pressure between surveys.

4. METHODS

4.1 FIELD SAMPLING

Temperature and dissolved oxygen measurements were made at six sites on the Clark Fork River in the vicinity of the Missoula WWTP and Stone Container discharges. These sites were:

1. just above the Missoula WWTP discharge;
2. at Shuffields (about 2 river miles below the Missoula WWTP);
3. at Harper Bridge (above Stone Container and 12 river miles below the Missoula WWTP);
4. at Huson (8 river miles below Stone Container);
5. at Alberton (19 river miles below Stone Container); and
6. at Cyr (25 river miles below Stone Container).

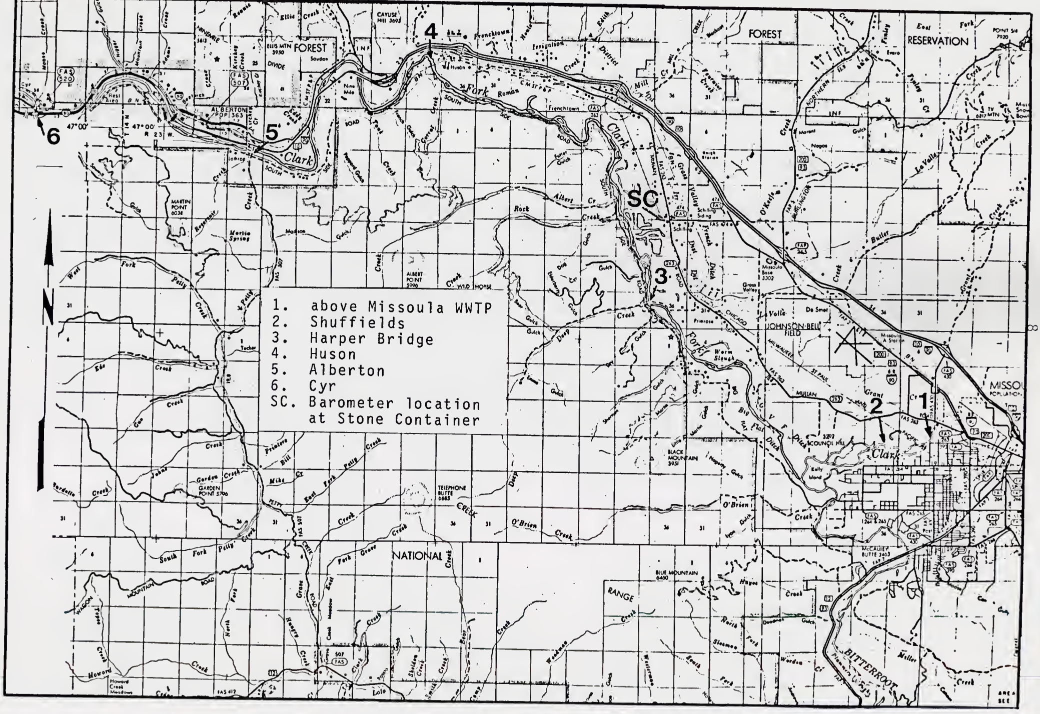
All sites except Cyr were regularly sampled during the EIS study. The sites at Harper Bridge and Huson were used by Stone Container for self-monitoring under terms of the discharge permit (Figure 1).

A schedule of sampling times at each station was predetermined. Dissolved oxygen and water temperature were usually measured at two-hour intervals. More frequent measurements were taken near the diel dissolved oxygen minimum and maximum.

Dissolved oxygen was measured using the azide modification of the Winkler method. Water temperatures were measured with mercury field thermometers calibrated in ^{o}C and accurate to $\pm$0.1 ^{o}C. Field thermometers were verified against a Bureau of Standards mercury thermometer. Field measurements were later corrected to true temperature. At a minimum, duplicate measurements of dissolved oxygen for quality control purposes were made near the beginning and again toward the end of each survey.

One Fortin-type mercurial barometer (Princo Instruments, 469 NOVA model) was mounted in the guard house at the main entrance to Stone Container. This location was approximately equidistant

FIGURE 1. Location of sampling stations on the Clark Fork River in the vicinity of the Missoula Wastewater Treatment Plant and the Stone Container Corporation kraft mill at Frenchtown.



from the sites furthest upstream and downstream. Barometric pressure and ambient air temperature were measured intermittently during the 24-hour period, generally at three to five hour intervals. Ambient air temperature was measured so barometric pressure readings could be corrected to standard temperature (0°C).

4.2 DATA ANALYSIS

Barometric pressure readings were corrected to standard conditions (standard temperature and standard gravity) and sea level (Appendix B). These values were then adjusted to the respective elevation at each sampling site so saturation concentrations could be calculated (Appendix C). Because barometric pressures were measured at different times than water temperatures and dissolved oxygen concentrations, true pressure at times of water temperature and dissolved oxygen measurement had to be interpolated.

Maximum and minimum values of water temperature and the dissolved oxygen concentration were field measurements. The maximum and minimum saturation concentrations were calculated from all measurements of water temperature taken during the period of monitoring and their corresponding interpolated barometric pressure values. Maximum and minimum values of percent saturation were calculated using all measurements of dissolved oxygen made during the period of monitoring and the corresponding saturation concentration at the time of measurement.

Average values of water temperature, dissolved oxygen concentration, and saturation concentration were time-weighted averages for the period of monitoring. The average percent oxygen saturation was calculated by dividing the average dissolved oxygen concentration by the average saturation concentration.

The estimate of dissolved oxygen production was calculated as:

$P = 2 \Delta DO$ (Mills et al., 1982) (5)

where:

P = estimate of dissolved oxygen production (mg/l/day)

ΔDO = difference between the maximum and minimum dissolved oxygen concentrations measured in mg/l.

5. RESULTS

5.1 SURVEY CONDITIONS

The two surveys were conducted July 9-10 and August 5-6, 1986. The weather during the first survey was unsettled. Showers and thundershowers passed through the study area, with occasional periods of clearing and sunshine. Temperatures were generally mild, rising to the low 70's (°F). The flow of the Clark Fork River was 2595 cfs above the confluence with the Bitterroot River and 4605 cfs below. The discharge flow from Stone Container was 9.0 cfs and instream dilution was 512:1.

The weather during the second survey was quite different from the first survey. Temperatures were in the mid-to-upper 80s (°F) and skies were mostly clear. Winds were often breezy in the late afternoon and early evening. The flow of the Clark Fork River was 1210 cfs above the confluence with Bitterroot River and 1920 cfs below. The discharge flow from Stone Container was 1.8 cfs and instream dilution was 1067:1.[1]

5.2 PERCENT OXYGEN SATURATION

In the following discussion the terms "percent oxygen saturation", "saturation concentration" and "dissolved oxygen concentration" refer to time-weighted average values unless otherwise specified. "Low discharge" and "high discharge" refer to the surveys conducted during the periods of low and high wastewater discharge, respectively, from Stone Container.

Tables 1 and 2 present maximum, minimum, and average values for percent oxygen saturation for all sites during high and low discharge. Water from the Clark Fork River above the Missoula WWTP and at Shuffields was similar in percent oxygen saturation during both surveys (103.4 - 106.9%). At Harper Bridge and sites downstream, water was more saturated during low discharge (106.4

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[1] Under terms of the discharge permit, no direct discharge from Stone Container is permitted when the flow in the Clark Fork River is less than 1900 cfs. When direct discharge does occur, instream dilution of the wastewater will be at a minimum 200:1 because of limits on the increase in color in the Clark Fork River.

Table 1 Temperature (T) and dissolved oxygen (DO) data during high wastewater discharge at stations on the Clark Fork River (CFR), July 9-10, 1986.

Site	Min. T.(°C)	Max. T.(°C)	Min. DO(mg/l)	Max. DO(mg/l)	Min. Satur. DO(mg/l)	Max. Satur. DO(mg/l)	Min. Percent Satur.	Max. Percent Satur.	Aver. T.(°C)	Aver. DO (mg/l)	Aver. Satur. DO(mg/l)	Aver. Percent Satur.	Est. of O_2/Prod. (mg/l/day)*
CFR above Missoula WWTP	15.6	17.2	8.65	9.85	8.52	8.83	100.8	114.0	16.6	9.23	8.63	106.9	2.4
CFR at Shuffields	15.7	16.9	8.40	9.80	8.58	8.81	97.6	113.7	16.5	9.13	8.65	105.5	2.8
CFR at Harper Bridge	15.7	17.3	7.80	10.10	8.52	8.84	89.0	118.5	16.5	8.83	8.67	102.4	4.6
CFR at Huson	15.9	17.6	8.00	9.85	8.48	8.82	90.7	116.2	16.8	8.83	8.65	102.1	3.7
CFR above Alberton	16.2	17.6	8.20	9.40	8.50	8.77	93.5	110.6	16.9	8.78	8.64	101.7	2.4
CFR at Cyr	16.3	17.6	8.40	9.20	8.51	8.77	96.0	108.1	17.0	8.80	8.63	102.0	1.6

* Estimate of O_2 production (mg/l/day) = 2 (Maximum DO - Minimum DO).

Table 2 Temperature (T) and dissolved oxygen (DO) data during low wastewater discharge at stations on the Clark Fork River (CFR), July 9-10, 1986. August 5-6, 1986

Site	Min. T.(°C)	Max. T.(°C)	Min. DO(mg/l)	Max. DO(mg/l)	Min. Satur. DO(mg/l)	Max. Satur. DO(mg/l)	Min. Percent Satur.	Max. Percent Satur.	Aver. T.(°C)	Aver. DO (mg/l)	Aver. Satur. DO(mg/l)	Aver. Percent Satur.	Est. of O_2/Prod. (mg/l/day)*
CFR above Missoula WWTP	17.1	19.9	7.80	9.95	8.01	8.55	91.9	124.2	18.4	8.76	8.29	105.7	4.3
CFR at Shuffields	17.0	20.0	7.50	9.80	7.99	8.57	87.8	122.4	18.3	8.59	8.31	103.4	4.6
CFR at Harper Bridge	16.7	20.5	7.05	10.95	7.94	8.65	82.4	138.0	18.7	8.80	8.27	106.4	7.8
CFR at Huson	17.5	20.8	7.10	10.65	7.90	8.52	83.8	134.7	19.2	8.75	8.20	106.7	7.1
CFR above Alberton	18.2	21.2	7.40	11.00	7.85	8.41	88.4	139.8	19.7	9.16	8.12	112.8	7.2
CFR at Cyr	18.4	20.7	7.70	10.60	7.95	8.39	92.0	133.3	19.7	9.02	8.14	110.8	5.8

* Estimate of O_2 production (mg/l/day) = 2 ,(minimum DO)

- 112.8%) than during high discharge (101.7 - 102.4%). In general, saturation between Shuffields and Alberton progressively increased during low discharge (103.4 - 112.8%) and decreased during high discharge (105.5 - 101.7%).

The percent oxygen saturation appears to have been affected more by the dissolved oxygen concentration than by the saturation concentration. During both surveys, the saturation concentration did not change much from site to site. This indicates that water temperature and atmospheric pressure were similar at all sites. The maximum change, a decrease of 0.08 mg/l, occurred between Huson and Alberton during low discharge. The largest change in the dissolved oxygen concentration between two sites was 0.25 mg/l during high discharge and 0.41 mg/l during low discharge. Changes in the percent oxygen saturation were fairly consistent with changes in the dissolved oxygen concentration from site to site for both surveys.

Values of minimum and maximum percent oxygen saturation indicate that important differences existed among the sites. These values are significant because two sites may be alike, on "average", but different in the diel profile defined by the maximum and minimum values. This was most evident at Harper Bridge and Cyr during high discharge. Average percent saturations were 102.4% and 102.0%, respectively, but minimum and maximum values were 89.0% and 118.5% at Harper Bridge and 96.0% and 108.1% at Cyr.

At each site, the difference between minimum and maximum percent saturation was greatest during low discharge. As was the case for average percent oxygen saturation, the maximum and minimum values of percent oxygen saturation appear to track the maximum and minimum values of dissolved oxygen more closely than the values of the saturation concentration.

Although the percent oxygen saturation is a useful expression of the relationship between the saturation concentration and the dissolved oxygen concentration, it is not very useful in quantifying site to site changes in dissolved oxygen. A change in percent saturation may be due to a change in

the saturation concentration, the dissolved oxygen concentration, or both. The following analysis evaluates the changes in these parameters at each site and between sites for each of the two surveys.

5.3 SATURATION CONCENTRATION AND DISSOLVED OXYGEN CONCENTRATION

Data from the Alberton site will be used as an example. During low discharge, the Clark Fork River here was most saturated (112.8%) and during high discharge it was least saturated (101.7%). Tables 3 and 4 summarize data for the saturation concentration and the dissolved oxygen concentration by site and survey. During low discharge, the dissolved oxygen concentration exceeded the saturation concentration by 1.04 mg/l (Table 3). During high discharge, the dissolved oxygen concentration exceeded the saturation concentration by only 0.14 mg/l.

The final column of Table 3 shows the relative change in these two parameters between surveys. At Alberton, this difference was 0.90 mg/l. The interpretation of this value is that the dissolved oxygen concentration exceeded the saturation concentration by 0.90 mg/l more during low discharge than during high discharge. Or, conversely, the dissolved oxygen concentration exceeded the saturation concentration 0.90 mg/l less during high discharge than during low discharge. The negative sign indicates the direction of the difference during high discharge relative to low discharge. The quantity of 0.90 mg/l represents the change in the dissolved oxygen concentration relative to the saturation concentration without quantifying the size or direction of the change in each parameter.

In Table 4, the data were arranged so the size of the change in the two parameters could be presented. At Alberton, the saturation concentration during high discharge was 0.52 mg/l greater than during low discharge. This estimates the change expected to occur in the dissolved oxygen concentration during high discharge if all variables except water temperature and atmospheric pressure were unchanged. However, the dissolved

Table 3 Average dissolved oxygen concentration (DO), average saturation concentration (SAT), and difference in concentration (DIFF) by survey, and difference between surveys, for stations on the Clark Fork River (CFR).

Site	Low Discharge (LD)			High Discharge (HD)			DIFF (HD)-DIFF(LD) (mg/l)
	Average DO (mg/l)	Average DO SAT (mg/l)	DIFF (LD) (mg/l)	Average DO (mg/l)	Average DO SAT (mg/l)	DIFF (HD) (mg/l)	
CFR above Missoula WWTP	8.76	8.29	0.47	9.23	8.63	0.60	0.13
CFR at Shuffields	8.59	8.31	0.28	9.13	8.65	0.48	0.20
CFR at Harper Bridge	8.80	8.27	0.53	8.88	8.67	0.21	-0.32
CFR at Huson	8.75	8.20	0.55	8.83	8.65	0.18	-0.37
CFR above Alberton	9.16	8.12	1.04	8.78	8.64	0.14	-0.90
CFR at Cyr	9.02	8.14	0.88	8.80	8.63	0.17	-0.71

Table 4 Average saturation concentration (SAT), average dissolved oxygen concentration (DO), difference in concentration (DIFF) between surveys, and difference between DO DIFF and SAT DIFF for stations on the Clark Fork River (CFR).

	Average SAT (mg/l)			Average DO (mg/l)			
Site	High Discharge	Low Discharge	DIFF (mg/l)	High Discharge	Low Discharge	DIFF (mg/l)	DO DIFF-SAT DIFF (mg/l)
CFR above Missoula WWTP	8.63	8.29	0.34	9.23	8.76	0.47	0.13
CFR at Shuffields	8.65	8.31	0.34	9.13	8.59	0.54	0.20
CFR at Harper Bridge	8.67	8.27	0.40	8.88	8.80	0.08	-0.32
CFR at Huson	8.65	8.20	0.45	8.83	8.75	0.08	-0.37
CRF above Alberton	8.64	8.12	0.52	8.78	9.16	-0.38	-0.90
CFR at Cyr	8.63	8.14	0.49	8.80	9.02	-0.22	-0.71

oxygen concentration actually decreased 0.38 mg/l during high discharge. The net result was a loss of 0.90 mg/l of dissolved oxygen -- a real loss of 0.38 mg/l and an unrealized gain of 0.52 mg/l expected because of differences in water temperature and atmospheric pressure.

The values in the final columns of Tables 3 and 4 may be interpreted differently. The value from Table 3 is described as a change in the exceedence of the saturation concentration by the dissolved oxygen concentration. This interpretation is most useful in explaining the change in percent saturation; that is, the decrease in the percent saturation of 112.8% to 101.7% resulted from a decrease of 0.90 mg/l in the difference between the dissolved oxygen concentration and the saturation concentration. The interpretation of the value from Table 4, that the decrease of 0.90 mg/l is a net loss of dissolved oxygen, best explains the real impact of the decrease in percent saturation. The interpretations are different but equivalent. A dissolved oxygen concentration which does not increase commensurately with the saturation concentration, or a saturation concentration which does not decrease commensurately with the dissolved oxygen concentration, represent a theoretical loss of oxygen from a system.

A similar analysis can be made for every other site. Above the Missoula WWTP and at Shuffields, the difference between the dissolved oxygen concentration and the saturation concentration during low discharge was slightly smaller than during high discharge (0.13 mg/l and 0.20 mg/l, respectively). However, from Harper Bridge to Cyr, this difference was much smaller during high discharge than during low discharge, equal to 0.32 mg/l at Harper Bridge and 0.71 mg/l at Cyr. At all six sites, the change was in the amount the dissolved oxygen concentration exceeded the saturation concentration. This is necessarily true because the average percent oxygen saturation was always greater than 100%.

Table 4 explains the real impact of these changes. The saturation concentration during high discharge was greater than during low discharge at all sites (0.34 mg/l above the Missoula

WWTP and Shuffields to 0.52 mg/l at Alberton). However, the dissolved oxygen concentration tended to increase in a downstream direction during low discharge while decreasing slightly in this same direction during high discharge. The net effect was that the dissolved oxygen concentration during high discharge, which was as much as 0.54 mg/l greater than the concentration during low discharge at Shuffields, decreased downstream to a concentration 0.38 mg/l less than the concentration during low discharge at Alberton.

The last column of Table 4 represents the net theoretical gain or loss in dissolved oxygen from the river. Above the Missoula WWTP and at Shuffields, the net gain of dissolved oxygen during high discharge was 0.13 mg/l and 0.20 mg/l, respectively. These gains were realized because the actual increase in the dissolved oxygen concentration exceeded that predicted by the saturation concentration. Below Shuffields, net theoretical losses of dissolved oxygen occurred during high discharge because the actual increases in dissolved oxygen concentrations were much less then predicted by the saturation concentrations. In fact, losses in dissolved oxygen were measured at Cyr and, as previously discussed, at Alberton during high discharge.

These data can also be used to calculate the changes which occurred between sites during the two different surveys. In Table 5, changes in the dissolved oxygen concentration and the saturation concentration which occurred between low discharge and high discharge at each site are arranged in order, upstream to downstream. The differences between sites in saturation concentration, dissolved oxygen concentration, and net differences are summarized in the columns between the site data.

For example, the difference in the saturation concentration between Huson and Alberton increased 0.07 mg/l during high discharge (compared to low discharge), reflecting differences in temperature and pressure at these sites. The difference in the dissolved oxygen concentration between Huson and Alberton during high discharge (compared to low discharge) decreased 0.46 mg/l. The net loss, representing a real loss of

Table 5 Differences in average dissolved oxygen concentration (DO DIFF) and average saturation concentration (SAT DIFF) between surveys, and calculated net loss in dissolved oxygen during high discharge at stations on the Clark Fork River (CFR) and changes (DIFF) between stations for all measures.

	CFR Above Missoula WWTP	DIFF (mg/l)	CFR at Shuffields	DIFF (mg/l)	CFR at Harper Bridge	DIFF (mg/l)	CFR at Huson	DIFF (mg/l)	CFR at Alberton	DIFF (mg/l)	CFR Above Cyr
SAT DIFF (High Discharge-Low Discharge) (mg/l)	+.34	0	+.34	+.06	+.40	+.05	+.45	+.07	+.52	-.03	+.49
DO DIFF (High Discharge-Low Discharge) (mg/l)	+.47	+.07	+.54	-.46	+.08	0	+.08	-.46	-.38	+.16	-.22
Net change in dissolved oxygen (mg/l)	+.13	+.07	+.20	-.52	-.32	-.05	-.37	-.53	-.90	+.19	-.71

(+) Sign in the site column indicates a higher value during high discharge than low discharge.
(-) Sign in the site column indicates a lower value during high discharge than low discharge.
(+) Sign in DIFF column indicates a larger value at downstream site.
(-) Sign in DIFF column indicates a larger value at upstream site.

0.46 mg/l and an unrealized gain of 0.07 mg/l, was 0.53 mg/l of dissolved oxygen.

Another approach to this analysis is useful. During low discharge, the saturation concentration decreased by 0.08 mg/l, from 8.20 mg/l at Huson to 8.12 mg/l at Alberton. The dissolved oxygen concentration at Huson was 8.75 mg/l. If the dissolved oxygen concentration at Alberton reflected the 0.08 mg/l decrease in the saturation concentration between the two sites, the measured concentration at Alberton would have been 8.67 mg/l. However, the measured concentration was 9.16 mg/l, or 0.49 mg/l more than expected. During high discharge, the saturation concentration decreased from 8.65 mg/l at Huson to 8.64 mg/l at Alberton, or 0.01 mg/l. However, the dissolved oxygen concentration decreased 0.05 mg/l (8.83 mg/l to 8.78 mg/l). Therefore, the real loss was 0.04 mg/l. However, another loss was the 0.49 mg/l increase which occurred between the two stations during low discharge, so that the theoretical net loss was 0.53 mg/l. A dissolved oxygen concentration of 9.31 mg/l at Alberton would have been necessary to reflect a like increase of 0.49 mg/l which occurred between Huson and Alberton during low discharge and the decrease of 0.01 mg/l which occurred in the saturation concentration during high discharge.

In summary, the following observations may be made:

1. The saturation concentration indicated greater differences between surveys in water temperatures and barometric pressures than between sites. The greatest difference between adjacent sites was 0.08 mg/l for either survey. Saturation concentrations were 0.34 mg/l to 0.52 mg/l greater during high discharge than during low discharge.
2. Changes which occurred in the dissolved oxygen concentration during high discharge were highly variable. The maximum increase, compared to low discharge, was 0.54 mg/l at Shuffields. The maximum decrease, compared to low discharge, was 0.38 mg/l at Alberton.

3. The largest decreases in the dissolved oxygen concentration during high discharge occurred between Shuffields and Harper Bridge (0.46 mg/l) and between Huson and Alberton (0.46 mg/l) relative to changes which occurred between adjacent sites during low discharge.
4. The greatest theoretical net loss in dissolved oxygen during high discharge occurred at Alberton (0.90 mg/l), because the increase in the saturation concentration and the decrease in the dissolved oxygen concentration were greatest at this site.
5. The greatest net theoretical loss of dissolved oxygen between sites during high discharge occurred between Huson and Alberton (0.53 mg/l). The loss between Shuffields and Harper Bridge was nearly as large (0.52 mg/l).

6. DISCUSSION

The objectives of this study were to determine whether wastewater discharges from the Missoula WWTP and the Stone Container kraft mill were responsible for measurable changes in dissolved oxygen in the Clark Fork River. Ideally, in the course of a two-survey study such as this, the only variable would be the amount of wastewater discharged to the river. However, several significant differences between the two surveys occurred which could have contributed to changes observed in dissolved oxygen concentrations.

One difference was the flow in the Clark Fork River. The flow during high discharge was approximately 1400 cfs more above the Bitterroot River and 2700 cfs more below the Bitterroot River than during low discharge. Differences in flow would have changed water depth, light penetration, and probably the amount of wetted and therefore biologically active stream bottom, altering community productivity and reaeration. Water temperatures were also a few degrees different, which may have affected community metabolism. The weather was quite different, characterized by intermittent showers and thundershowers and mild temperatures during high discharge, and very warm temperatures, clear skies, and moderate winds during low discharge. Large differences in light intensity would be expected to affect community productivity, and differences in water temperature and wind speed could affect reaeration rates.

In general, water temperature and barometric pressure did not differ much from site to site so that minimum, maximum, and average saturation concentrations were quite comparable among all sites. These concentrations differed more between surveys because of differences in average water temperature and greater diel changes which occurred during the low discharge survey.

The data suggest that a significant change occurs at Harper Bridge. The sites above the Missoula WWTP and at Shuffields were very similar in many measures but different from the lower four sites (maximum dissolved oxygen concentration, maximum percent saturation, average temperature, and the estimate of oxygen

production during low discharge; and average dissolved oxygen concentration and average percent saturation during high discharge). Some measures, such as the minimum dissolved oxygen concentration, the minimum percent saturation, and the estimate of oxygen production for both surveys, suggest the presence of an impact zone beginning at Harper Bridge. Values for these measures change significantly between Shuffields and Harper Bridge and gradually return to values more like those found at the two upstream sites.

These observations may be related to several factors. The Bitterroot River enters the Clark Fork River between Shuffields and Harper Bridge. During high discharge, the Bitterroot River contributed 43.6% of the flow at Harper Bridge. During low discharge, its contribution was equal to 37.0%. The Bitterroot River's large contribution of relatively clean water probably influences the results at Harper Bridge. The Missoula WWTP discharge may also be causing an impact on the Clark Fork River in the area of Harper Bridge. Studies conducted for the Champion International Discharge Permit EIS found that the periphyton community composition and structure were slightly stressed at Harper Bridge when compared to sites above the Missoula WWTP (Montana DHES, 1985). Unpublished data (Weber, 1986) also indicate the standing crop chlorophyll _a_ concentration to be highest at Harper Bridge of all the lower river sites tested. Therefore, it may not be that surprising to see responses at the two upstream sites to be similar in many respects, yet different from the four lower sites. Data from the two upstream sites are valuable because they indicated that in spite of differences in river flow, water temperature, weather, etc. between the two surveys, changes in the dissolved oxygen concentration were fairly consistent with changes in the saturation concentration. This was not true at the four lower sites.

The estimates of dissolved oxygen production (Equation 5) are useful in evaluating differences in productivity among the sites. These estimates (Tables 3 and 4) were quite variable, but were consistently lower during high discharge than during low

discharge. A comparison of these estimates indicates that oxygen production became more depressed at each site below Shuffields during high discharge. As a percentage of the estimated oxygen production during low discharge, the estimates of oxygen production during high discharge were:

1.	above the Missoula WWTP	56%
2.	Shuffields	61%
3.	Harper Bridge	59%
4.	Huson	52%
5.	Alberton	33%
6.	Cyr	28%

This trend is significant for several reasons. First, the estimate of oxygen production, perhaps more than any other measure in this study, is a significant indicator of benthic community metabolism. Secondly, it suggests that some factor other than differences in water temperature, weather, or river flow was responsible for the proportionately lower estimates at Alberton and Cyr, and perhaps Huson, during high discharge. For example, differences in weather or water temperature between surveys would probably be similar at all stations. The ratio of the estimates of oxygen production during high discharge to the estimates of oxygen production during low discharge would probably be much more alike if weather or water temperature were the only variable factors.

A study of riffle community metabolism above and below the kraft mill discharge (Kicklighter and Stanford, 1985) supports this study's conclusion that oxygen production was depressed at sites below Huson. Riffle community metabolism was studied at two sites above the kraft mill discharge and at two sites below the discharge in November 1984, and April and August, 1985. The study concluded that there was generally no significant difference in net community primary productivity, gross primary productivity, or diel respiration between riffle sites located above the kraft mill and those downstream of it. However, the data showed a significant difference in net community primary productivity and gross primary productivity between the Ninemile

site (just above Alberton) and the other three sites in August, though not in November or April. Since diel respiration at Ninemile was similar to the other sites, oxygen production during the day had to be less at Ninemile than at other sites to result in a significantly lower net community primary productivity and gross primary productivity. This supports this study's findings of depressed oxygen production at sites below Huson during the survey conducted in July.

6.1 MISSOULA WWTP DISCHARGE

The discharge from the Missoula WWTP, as previously discussed, is believed to have a maximum impact on the Clark Fork River in the vicinity of Harper Bridge. In this study, a theoretical loss of dissolved oxygen of 0.52 mg/l was calculated between Shuffields and Harper Bridge during high discharge. This was surpassed only by the theoretical loss of 0.53 mg/l of dissolved oxygen between Huson and Alberton. Because the Bitterroot River enters the Clark Fork River between Shuffields and Harper Bridge, it may be difficult to define the interactions of both rivers and the wastewater discharge.

The Missoula WWTP discharge flow, on a day-to-day basis, is fairly constant. Assuming an average flow of 12 cfs, instream dilution of the discharge during the high discharge survey was 384:1. During the low discharge survey, instream dilution was 160:1. Instream dilution of the Stone Container discharge was 512:1 and 1067:1, respectively, during these two surveys. The instream dilution ratios are important because they show that during the survey in which the dilution of kraft mill wastewater was highest, the dilution of the WWTP discharge was lowest, and vice versa. Because instream dilution of the WWTP discharge was lowest during the low discharge survey, the theoretical loss of dissolved oxygen between Shuffields and Harper Bridge during high discharge, when instream dilution of the WWTP discharge was greater, seems paradoxical. If there was relatively less wastewater, and probably lower nutrient concentrations, instream during high discharge than during low discharge, then the

expected change in dissolved oxygen between Shuffields and Harper Bridge during high discharge would have been a theoretical gain in dissolved oxygen rather than the observed loss of 0.52 mg/l. One explanation might be a much poorer quality effluent during high discharge than during low discharge. Also, the water quality of the Bitterroot River might have been significantly different during the surveys.

6.2 STONE CONTAINER DISCHARGE

The data in this study indicate that the Stone Container discharge may be influencing dissolved oxygen concentrations in the Clark Fork River below Huson. The greatest theoretical loss of dissolved oxygen during high discharge occurred between Huson and Alberton, equal to 0.53 mg/l. The greatest decrease in the dissolved oxygen concentration during high discharge occurred at Alberton, equal to 0.90 mg/l. This study, supported by Kicklighter (1985), indicated that oxygen production in the Clark Fork River below Huson was depressed during high discharge relative to low discharge. The significance of the Stone Container wastewater discharge to the observed changes and theoretical losses in dissolved oxygen is difficult to assess without further study.

One important observation is that responses at Harper Bridge and Huson were similar during high and low discharge. The differences in the saturation concentrations and the dissolved oxygen concentrations between surveys at these sites were almost the same (Table 5). The changes between Huson and Alberton indicate that this may be the impact zone of the Stone Container discharge and that self-monitoring sites at Harper Bridge and Huson may not be useful in detecting maximum impacts of the Stone Container discharge on in-stream dissolved oxygen. However, the data also indicate that these sites are appropriate in preventing a violation of the water quality standard for dissolved oxygen. These two surveys, as well as the surveys of 1984 and 1985, showed that the lowest diel dissolved oxygen concentrations occurred at Harper Bridge, and that at sites further downstream

the minimum diel dissolved oxygen concentration progressively increased. Therefore, a standard of dissolved oxygen concentration which is met at Harper Bridge would likely be met at sites further downstream.

In summary, this method appears to be useful in calculating changes in dissolved oxygen in different reaches of a river. The method requires two surveys, one which serves as a "baseline" for comparison, and another which includes a change in some variable. The bases for comparison are saturation concentrations of dissolved oxygen predicted by water temperature and barometric pressure. Changes in dissolved oxygen concentrations "expected" to occur between sites or at one site during two surveys are estimated from changes in saturation concentrations. Measured dissolved oxygen concentrations reveal whether changes which do in fact occur are consistent with changes expected to occur.

7. CONCLUSIONS

Monitoring during a period of high and low wastewater discharge from Stone Container indicated some significant differences between the two surveys. However, a direct cause/effect relationship between the volume of wastewater discharged and observed changes in dissolved oxygen cannot be made. Some important findings are:

1. Harper Bridge appears to be the most productive site in terms of estimated dissolved oxygen production.
2. The diel minimum dissolved oxygen concentration was lowest at Harper Bridge and gradually increased at sites further downstream, suggesting that a standard or concentration met at Harper Bridge would not be violated at sites further downstream at wastewater discharge rates equal to or less than those occurring in this study.
3. During high discharge, the net theoretical decrease in dissolved oxygen between Shuffields and Harper Bridge and between Huson and Alberton were the most severe relative to changes which occurred during low discharge.
4. Estimates of dissolved oxygen production indicate some depression at Huson and at sites further downstream during high discharge, relative to estimated production during low discharge.
5. Differences in river flow and weather conditions during the two surveys may have been responsible for some of the observed changes.
6. Changes which occurred between Harper Bridge and Huson during high discharge were very similar to changes which occurred during low discharge.

8.0 RECOMMENDATIONS

Although this method appears to be useful, no direct cause/effect relationship between the Stone Container discharge and observed changes in dissolved oxygen concentration could be established. To strengthen such a cause/effect relationship, more control would have to be exerted over other variables. Perhaps a controlled discharge/no discharge type of study only a few days apart would minimize changes in river flow, water temperature, and weather conditions. Another suggestion would be to collect additional information during such a study, such as water quality data, or periphyton samples for taxonomy or chlorophyll a analysis. Finally, a greater number of surveys would provide more conclusive and persuasive evidence of direct cause/effect relationship if carefully planned and executed.

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10. APPENDICES

Appendix A. Description of method of computing time-weighted average dissolved oxygen concentration, time-weighted average saturation concentration, and time-weighted average temperature.

The time-weighted dissolved oxygen and temperature values in Tables 1-5 were computed as follows. For each station a 1-day period was chosen that centered around the approximate 1-day period over which the diurnal sampling was done. The time-weighted values were calculated by the following formula:

$V_{tw} = V_1 \ (dT)_1 + V_2(dT) + \ldots = V_n \ (dT)_n,$

where $V_1 \ldots V_n$ are the measured values of dissolved oxygen or temperature over the approximate 1-day period, and $(dT)_1 \ldots (dT)_n$ are the time intervals in days associated with each of the n samples.

The time interval for a given sample begins at the midpoint to the previous sample and ends at the midpoint to the next sample with two exceptions: The first time intervals begins at the beginning of the chosen, exact 1-day period and the last time interval ends at the end of that period.

The time-weighted values are close approximations to those that would be obtained if samples were taken at exact, regular intervals and simply averaged without any weighting. Thus the weighting is done to compensate for the irregularity of the time intervals between samples.

Source:MDHES (Montana Department of Health and Environmental Sciences). 1985. Environmental Impact Statement for Champion International Frenchtown Mill Discharge Permit, MT-0000035. Data Report - Volume 1. Environmental Sciences Divison, Water Quality Bureau, Helena, Montana.

Appendix B. Description of method for correcting an observed barometer reading to standard temperature and standard gravity (standard conditions).

The equation for correcting an observed barometer reading to standard temperature (0°C) is:

$$C_t = p_t - p_r = p_r\ (1 + Lt - Lt_s)/(1 + Mt - Mt_m) - p_r$$

The equation for correcting an observed barometer reading at standard temperature to standard gravity is:

$$Cg = p_l - p_t\ (0.99995 - 0.0026372\cos 20 + 0.0000059\cos 20) - p_t$$

The equation for correcting an observed barometer reading at standard temperature and gravity (standard conditions) to sea level:

$$p_s = p_o - p_o\ (1 - 0.0065M/288.16)^{5.2561}$$

Where: C_t = temperature correction
C_g = gravity correction
H = geopotential (elevation above sea level in meters)
p_l = local station pressure
p_o = standard pressure at sea level (29.921 inches, 760 millimeters, 1013.25 millibars)
p_r = uncorrected barometer reading
p_t = temperature corrected barometer reading
t = temperature, Celsius
0 = latitude, degrees north or south
L = 0.0000184 $m/m^{o}C$
M = 0.0001818 $m^3/m^{3o}C$
t_m = $0^{o}C$
t_s = $0^{o}C$
p_s = sea level differential for standard conditions

Source: Instruction booklet for use with Princo Fortin-type Mercurial Barometers, Princo Instruments, Inc. Southhampton, Pennsylvania.

Appendix C. Example illustrating correction of an observed barometer reading to standard conditions, and its conversion to barometric pressure at monitoring sites on the Clark Fork River.

Date and Time: July 9, 1986 at 10:15 a.m.

observed barometer reading:	684.7 mm.
air temperature:	21.7°C
elevation of barometer:	3060 feet
latitude of barometer:	46° 58' (46.97°)

observed barometer reading:	684.7 mm.
temperature correction:	- 2.42 mm.
temperature corrected reading:	682.28 mm.
gravity correction:	+ 0.09 mm.
local station pressure:	682.37 mm.
sea level differential:	+80.35 mm.
	762.72 mm.

STATION	ELEVATION	ELEVATION CORRECTION
above Missoula WWTP	3150	-82.57
at Shuffields	3140	-82.33
at Harper Bridge	3050	-80.10
Stone Container Gate	3060	+80.35
at Huson	2990	-78.60
at Alberton	2950	-77.58
at Cyr	2900	-76.31

Corrected barometric pressure calculated for sea level (762.72 mm) and recalculated for site elevation difference:

Cyr: 762.72 mm - 76.31 = 686.41 mm

4. CONCLUSIONS

The FY 1987 monitoring period was a low snowpack, low streamflow year. Streamflows peaked a month ahead of schedule in spring 1987 and the runoff period was brief. As a result, data evaluations for streamflow dependent variables in the Clark Fork system, such as metals and sediment, probably are not representative of more normal runoff years.

Clear downstream trends in pollutant concentrations and severity scores were apparent in the FY 1987 monitoring data. Silver Bow Creek above the Warm Springs treatment ponds was severely polluted with metals and nutrients and moderately polluted with suspended sediment. All pollutants measured decreased significantly below the treatment ponds due to settling and biological assimilation.

From Warm Springs to the confluence of Rock Creek, the river can be categorized as variably and seasonally stressed from metals, nutrients and sediment. One station, the Clark Fork above the Little Blackfoot River, stood out as the most stressed of all the mainstem stations.

Water quality conditions for all parameters generally improved below clean water tributaries like Rock Creek and the Bitterroot and Flathead Rivers. However, water quality was degraded for at least short distances below Milltown Dam and the Missoula and Stone Container Corporation wastewater discharges. No water pollution problems were evident in the Clark Fork below the Flathead River in FY 1987.

Conclusions relevant to the macroinvertebrate and periphyton data and dissolved oxygen monitoring can be found in those reports.

5. DISCUSSION

A general overview of surface water quality trends in the Clark Fork River drainage in FY 1987 was given in the preceding pages. Admittedly, the treatment of the data has been somewhat superficial due to the sheer volume of material and the limited amount of time between the end of FY 1987 sampling and the contract deadline. Much of the available time was spent verifying raw data and computer printouts, compiling USGS streamflow data and creating computer graphics.

During the continuation of the monitoring program over the next two years, data analysis techniques will be refined and the biological information will be computerized. It is the goal of the author to develop an efficient means of accurately assessing water quality conditions in the Clark Fork drainage from year to year through the automated processing of annual monitoring data.

Three years of nearly complete Clark Fork monitoring data (FY's 1985 - 1987) are now on the computer data base. The first two years of information were collected by the DHES Water Quality Bureau for the EIS on the Champion International (now Stone Container) Corporation kraft mill wastewater discharge and to look at metals levels in the Clark Fork headwaters. These earlier data are yet to be fully evaluated. During the course of the next six to eight months, all three years' data will be comprehensively evaluated and discussed in a single report. That evaluation will serve as the basis for analysis of conditions and trends in subsequent monitoring data.

One thing seems clear. The monitoring program and data assessment scheme used in FY 1987 is reasonably sensitive to the various water quality problems and activities occurring in the basin. The elevated metals and sediment levels created by the Milltown Dam reconstruction were very evident in the evaluations as were the nutrient impacts of the Butte and Missoula wastewater discharges. A combination of metals, nutrients and sediment impacts point to monitoring station 10, the Clark Fork above the

Little Blackfoot River, as an area of stress. This coincides with observations by the Montana Department of Fish, Wildlife and Parks of depressed trout numbers in this reach of river. The program works and, with refinement, it will become a valuable yardstick by which to gauge our continuing water pollution control efforts in the drainage.

6. REFERENCES CITED

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7. APPENDICES

River Mile Index to Facilitate the Review of Data Plots

Number	Monitoring Station	River Mile
00	Silver Bow Creek (SBC) above Butte Wastewater Treatment Plant	0.0
01	SBC below Colorado Tailings	1.0
02	SBC at Miles Crossing near Ramsay	11.0
03	SBC above Warm Springs (ACM) treatment ponds	22.0
04	ACM Pond #2 discharge (Silver Bow Creek)	26.0
05	Mill-Willow Creek bypass at mouth	26.0
06	Warm Springs Creek at mouth	27.5
07	Clark Fork (CFR) below Warm Springs Creek	28.0
08	CFR near Dempsey	36.0
09	CFR at Deer Lodge	49.0
10	CFR above Little Blackfoot River	64.0
11	CFR Gold Creek Bridge	74.5
12	CFR at Bonita	124.5
13	CFR at Turah	141.5
14	Blackfoot River near mouth	147.5
15	CFR below Milltown Dam	150.0
16	CFR above Missoula WWTP	157.4
17	Missoula WWTP discharge	157.5
18	CFR at Shuffield's	159.5
19	Bitterroot River near mouth	162.5
20	CFR at Harper Bridge	170.0
21	Stone Container Corporation discharge 003	173.5
22	CFR at Huson	182.0
23	CFR at Alberton	192.5
24	CFR at Superior	230.5
25	CFR above Flathead River	270.0
26	Flathead River near mouth	270.5
27	CFR above Thompson Falls Reservoir	294.5
28	CFR below Thompson Falls Dam	314.5
29	CFR below Noxon Rapids Dam	351.5
30	CFR below Cabinet Gorge Dam	373.5